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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JULY 1959

FULL TEXT OF THE NASA
SPACE SCIENCES PROGRAM

IGY REPORT:

Herbert Friedman • Robert Jastrow • Warren W. Berning • Leslie M. Jones • Julian C. Holmes • Charles Y. Johnson • Conrad Josias

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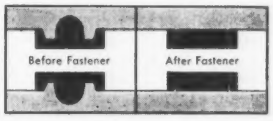

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Astro notes

MAN IN SPACE

• The man-in-space program went through some tuning-up exercises with successful recovery alive of the simian astronauts, Able and Baker, after a 1500-mile flight in a Jupiter missile (see page 48), and the predicted launching of a Discoverer satellite carrying four mice. Unfortunately, the Discoverer did not achieve an orbit, there being indications that the second stage fired the satellite down into the atmosphere.

• An experiment with sea urchin eggs in the Able-Baker flight showed that pre-fertilized eggs continued to develop over the trajectory. Eggs fertilized during the launching disintegrated owing to an improper fixative. More of these biomedical experiments can be expected as the schedule of NASA "Little Joe" capsule-test firings begins this fall.

• NASA is planning two early test flights of the Project Mercury capsule using Atlas-D boosters. Scheduled for late this summer or early fall, the capsules will be fired on a grueling 1700-mile up-and-down trajectory to expose them to the maximum heat and deceleration stress they will encounter on reentry from orbit. Purpose of the tests is to confirm the engineering approach to the capsule as soon as possible, particularly with respect to the behavior of ablation materials over the wide surface of Mercury's heat shield.

• The configuration of the Mercury capsule is still somewhat fluid. One recent change resulted in abandonment of the inflatable bag to cushion the capsule on impact after its return from orbit. Instead of the bag, NASA will probably use an aluminum honeycomb structure located between the heat shield and the pressure plate of the capsule. Big advantage of the honeycomb cushion is that it involves no switches or valves to misbehave.

• Space Electronic Corp. will study the design of a Project Mercury control center under NASA contract.

• McDonnell Aircraft subcontracted development of attitude-control rockets for the Mercury capsule to Bell Aircraft's Niagara Frontier Div. A paper (ARS preprint 790-59) from the ARS Controllable Satellites Conference suggests Bell approach to the control-rocket problem.

• NASA is considering three possible spacesuits for the Mercury astronauts. It is inspecting garments developed for military use by International Latex Co., David Clark Co., and B. F. Goodrich Co. Suits chosen by NASA must be capable of operation at an internal pressure of 5 psi, or somewhat higher than the 3.5 psi (35,000 ft equivalent) required by the military services.

• The Navy's Air Crew Equipment Laboratory, Philadelphia, is planning a series of experiments with pressurized space capsules in high-altitude chambers. The experiments will include studies of atmosphere control inside space capsules. ACEL also expects to support NASA's program to develop the two-man vehicle which will follow the Mercury capsule. The latter, as yet unnamed, would require one crewman to wear a pressure suit at all times while the other remained in a crew rest station. The two-man vehicle would be put into orbit by a Vega propulsion system.

SATELLITES

• For the past few months, a special Navy board has been mapping a future Navy astronautical program. One area in which the Navy has a definite interest—submarine surveillance satellites.

• Satellites and deep-space probes are the order of the day as ASTRONAUTICS goes to press, with Vanguard III and Explorer VI satellite launchings scheduled and Thor-Able and Atlas-Able probes possible late in the month.

• Long-lifetime satellites, such as the Explorer VI, will contain either a self-destruct device or a ground-controlled circuit breaker to terminate transmitter operation. The silencing of satellite transmitters and the allocation of radio frequency bands will be discussed at the International Telegraphic Union in Geneva next month.

• As described by James Kupperian Jr., at the ARS Semi-Annual Meeting, held last month in San Diego, NASA's first astronomical satellite will weigh 2500 lb and carry perhaps as many as six telescopes. It will probably be launched by a Vega system in two years.

• NASA's planned high-mass, low-drag geodetic satellite will traverse a higher orbit than Vanguard I to avoid atmospheric drag as much as possible. Measurements on Vanguard I, incidentally, are almost precise enough to disclose the relativistic shift of perigee predicted by Albert Einstein.

• A novel tracking technique may be employed with this geodetic satellite: Batteries of ground searchlights coupled with corner-cube reflectors installed on the satellite. The latter, reflecting the searchlight beams directly back to the source, would permit optical detection at 500–1000 miles altitude. NASA scientists want either optical or radar tracking of the geodetic satellite, since either is more precise than the Minitrack system.

• Gravity experiments under study involve orbiting a very accurate atomic clock to determine whether there is a time acceleration effect in weak gravitational fields, as predicted by Einstein.

• Many scientists believe that gravitational experiments now made possible by satellite technology will lead to a breakthrough in understanding the physics of the universe. For example, it will be possible to test the hypothesis that gravitational attraction is a function of the average density of the universe, and that it is gradually weakening as the universe expands. This idea can be tested by comparing a gravitational measure of time —made with the geodetic satellite mentioned above—with a very accurate atomic clock on earth. If the latter appears to run faster over a period of time, it will indicate that the gravitational bonds of the universe are steadily weakening.

SPACE RADIATION

• Pioneer IV Geiger counters detected more than three times the number of particles in the earth's radiation field than did Pioneer III (see page 32). All of the newly detected particles were in the outer of the earth's two radiation belts, which extended almost 20,000 miles farther into space than it did in December. The jump in particle population was attributed to a major solar disturbance six days before the flight of Pioneer IV.

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• Most important of Pioneer IV's findings related to the energies of the charged particles trapped in the two belts. One counter, shielded with slightly more than one-sixth of an inch of lead, detected almost no radiation in the outer belt, although its counting rate was relatively unaffected in the inner belt. Not only does this constitute additional evidence for the solar origin of the particles in the outer belt, and the cosmic ray origin for the inner belt particles, it also has important implications for the future of manned spaceflight.

• The radiation findings mean that spacecraft can be protected against the low-energy particles of the outer belt with relatively small weights of shielding. Although shielding of the inner belt particles will probably be prohibitive, the fact that the belt is only 2000-miles thick and is close to the earth means that spacecrews will be exposed only about 5 min to the penetrating radiation during lunar and interplanetary hops.

• The new data seemed to confirm S. Fred Singer's theory that the inner radiation belt is composed of charged particles injected into the geomagnetic trap by decaying neutrons produced by cosmic ray collisions with the atmosphere. Official confirmation of Dr. Singer's theory came from two Univ. of California physicists, Stanley C. Freden and R. Stephen White. After studying photographic plates carried to a maximum of 770 miles aboard a Thor-Able nose cone recovered from the South Atlantic in May, the two scientists concluded that the charged-particle population of the inner radiation belt includes protons ranging in energy from 75 to 700 mev. They attribute the protons to the decay of neutrons resulting from the collision of cosmic rays with the upper atmosphere, as predicted by Singer, and others, more than a year ago. Dr. Singer's proposal to sweep the inner zone free of radiation with large aluminum spheres may turn out to be a practical answer to the radiation threat to manned space stations.

NASA

• NASA has just formed a committee to study need and technical requirements for an equatorial launching site. ARPA, ABMA, Rand Corp., and JPL are represented on the committee.

• The newly formed NASA Committee for Long-Range Studies will deal with international, social, economic, and legal facets of space research and exploration. John A. Johnson, NASA's general counsel, chairs the committee.

• NASA expects that its contracts for research and development will continue on a cost-plus-fixed-fee basis for some time to come.

• Hearings before the Senate saw restoration of the House-cut $4.75 million requested by NASA for construction of a central facility for development of high-energy propellants. Thus, NASA's whole fiscal 1960 budget of $485.3 million was approved as originally requested.

ARPA

• Of the $410.5 million programed by ARPA through fiscal 1959, almost $240 million went to Lockheed, primarily for work on Discoverer, Midas, and Sentry.

• ARPA's Project Orion, which would put a space platform weighing many tons in orbit with a propulsion system powered by atomic-bomb capsules, has its problems of shielding and fallout. General Atomic Div. of General Dynamics is studying the system under a million-dollar ARPA contract.

TRACKING

• Survey teams from both the Atlantic and Pacific Missile Ranges have been looking over proposed sites for an equatorial launching range. While no site has as yet been selected, the decision is expected to be made some time this year. When the equatorial range is completed, an interconnected worldwide range will be established, allying all of the present launching ranges in the Free World. Some $2.5 billion is expected to be spent on the global range over the next 15 years.

• The Space Track operation, sponsored by ARPA, will be expanded to include capacity to handle data from new tracking networks as they come into being.

• Range experts note that Russia is at a definite disadvantage when it comes to an equatorial launching, since no Soviet-controlled land mass is on or near the equator.

COMMUNICATIONS

• Experts say radio communications as far out as Mars are possible today, noting that, if sufficient battery power had been available, effective communications could have been maintained with Pioneer IV for a million and a quarter miles.

• George Mueller of STL noted at the May Telemetering Conference in Denver (see page 64) that communications experts face two very different problems in future astronautical experiments. The first is reduction and analysis of data from long-lived satellites. The need here is for a wideband telemetry system which will permit easy data reduction. The second is development of a reliable narrowband system for long-range missions that would make it possible to distinguish a signal from background noise.

SPACE LAW

• The first meeting of the UN Committee on Peaceful Uses of Outer Space failed to develop any forceful leadership from the U.S., which seemingly shows a strong preference for leaning on existing international law to solve legal problems of spaceflight, in particular, that of air space. Comments from representatives of other nations on the committee? Mayayoshi Kakitsubo of Japan: "If human activities in outer space are left unregulated to permit 'the growth of customary international law through the accumulation of *fait accompli*,' this might prove to be detrimental to the future establishment of a rational regime in outer space." Fereydoun Adamiyat of Iran: "It would be unwise to delay too long the study of possible solutions to the legal problems involved, since this could lead to 'undesirable rivalries' and international misunderstandings. There is no legal basis for claiming that international law can be interpreted to mean that absolute national sovereignty in airspace could be extended to outer space, and it is not a 'sound proposition' to say that existing international law and 'the law of the United Nations' are applicable to outer space."

BUDGET

• A process which the Administration started last year with its cancellation of the Regulus II and Goose airbreathing missiles was continued with a vengeance by the House Defense Appropriations Subcommittee in its recommendations for the Pentagon's fiscal 1960 budget. The lawmakers whacked off $127.5 million requested for procurement of the Martin's Mace and $162.7 million sought for Boeing's Bomarc. At the same time, they voted a $200 million increase in

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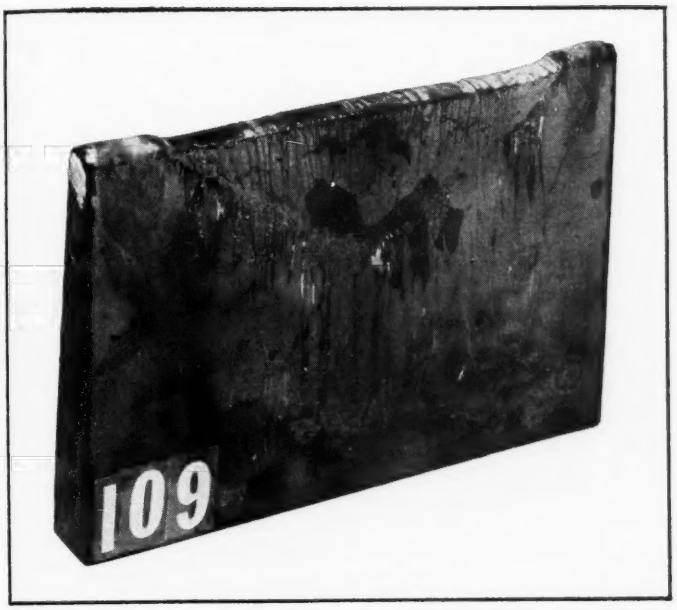

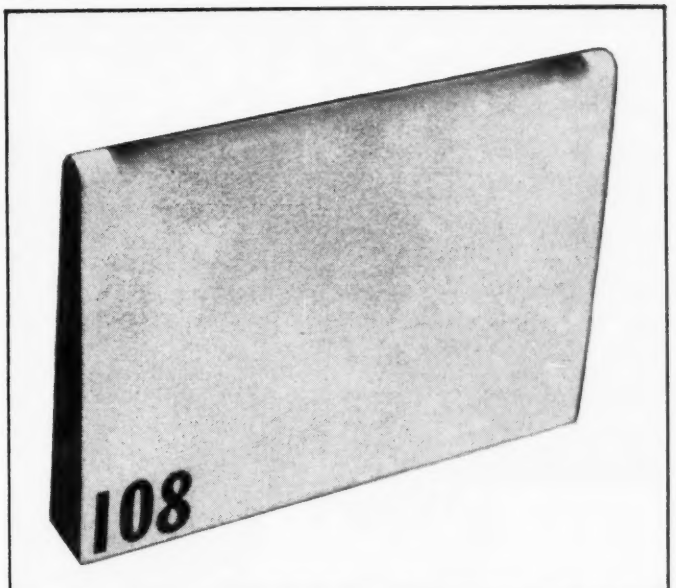

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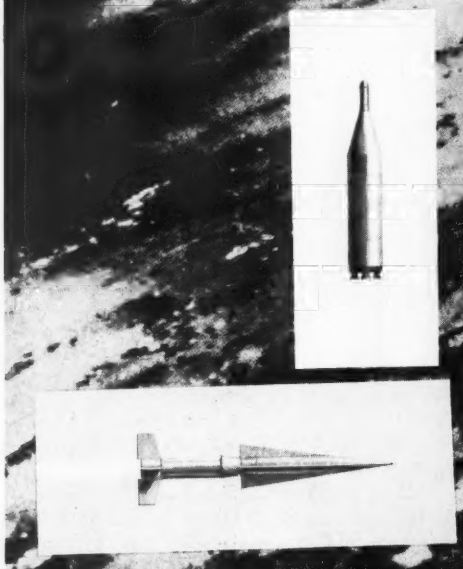

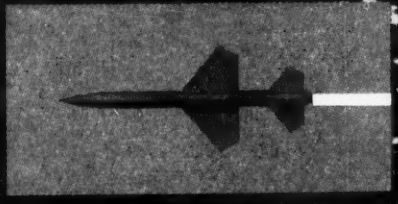

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The earth from 100 miles up, taken by Navy camera, shows 200,000 square miles of U. S. and Mexico.

the Army's Nike-Zeus anti-missile program, $87 million more to accelerate the Minuteman program, and $85 million as a "down payment" for establishment of eight additional Atlas squadrons.

• The Senate Armed Services Committee, in turn, refused to authorize an Army request for Nike-Hercules construction money. The picture was further confused when the House voted the procurement funds sought for Hercules and slashed the Bomarc.

• The lawmakers were clearly unhappy with the enormous outlays required for the Hercules and Bomarc. By the first of this month, they estimated, commitments for Hercules totaled almost $3.7 billion, while Bomarc commitments reached $1.9 billion. But an even more fundamental objection to Hercules and Bomarc concerned the military utility of these weapons in view of the advent of the long-range ballistic missile.

MISSILES

• The whole question of air defense, which has acquired a dull focus in the debate over the merits of Bomarc and Nike-Zeus, went to the highest levels of DOD, with Secretary of Defense Neil McElroy expected to shine a bright light through the haze of propaganda surrounding this issue. In an address at the annual Aviation Writers Assn. meeting, Joseph V. Charyk, Air Force Chief Scientist, made it seem like quite a problem to counter the ballistic missile launched from dispersed, and even partially hardened, bases and equipped with anywhere up to 200 decoys of different kinds for confusion of anti-missiles directed by radar. The cost of effective defenses, as currently envisioned, against even a few hundred such missiles would be astronomical.

• In the same meeting, H. L. Richardson, senior vice-president of Sylvania Electric Products, suggested novel possibilities for missile detection and neutralization which have scarcely been broached—among them, destruction or deflection of an incoming warhead with a flux of electromagnetic energy; deflection of the missile in a similar manner during launching, by development of a means to bend electromagnetic energy; and disturbing the aerodynamic properties of a missile enough to cause it to burn up on re-entry. The ARPA-sponsored satellites and missile-defense projects presumably venture onto this ground.

• Meanwhile, the Army awarded Olin Mathieson a half-million dollar contract to explore the uses of an "advanced propellant" for Nike-Zeus; Grand Central Rocket announced successful static-firing of the tactical sustainer for this missile; and the construction of nearly $4 million in launching and associated test facilities for Nike-Zeus proceeded at full steam at White Sands.

• Also, the first advanced version of Boeing's Model-B Bomarc, which employs a Thiokol solid booster, instead of a liquid booster, and twin Marquardt ramjets to achieve a range greater than 400 miles, was launched from Cape Canaveral and successfully tested in maneuvers.

• The failure of the fifth "operational" Atlas in a row, the last one 2 min after launching from Cape Canaveral early in June, led an Air Force spokesman to comment that troubles with Atlas might postpone plans to declare the missile operational this month. The missile is having booster-separation problems. An operational Titan would appear to be two year's away.

• Martin's Orlando Div. received a $15 million Army contract for additional production of Lacrosse missiles and engineering services, bringing the total contract awards to Martin for Lacrosse since Jan. 1959 to over $25 million.

• Convair's Red Eye may be the smallest anti-aircraft guided missile yet developed. The infrared weapon is designed to be fired from a bazooka-type launcher. The projectile, which has a range of about 1000 yd, is said to be highly effective against low-flying targets.

R&D

• The USAF budget request for fiscal 1960 includes a $23 million item for an "anti-radiation missile" designated WS-121B. No design competition has been reported for the weapon as yet. Presumably it would be used as a penetration aid by bombers of the Strategic Air Command. As a "radar buster," the missile could be used to home on enemy radar antennas, thus harassing missile and interceptor defenses.

• Decision on the contractor team to develop the boost-glide Dynasoar has reportedly been delayed by the death of Donald Quarles, late Deputy Secretary of Defense. It is understood that Dr. Quarles was expected to pass on the USAF decision. The teams competing for the 8000–10,000 mph Dynasoar vehicle are led by Boeing and Martin.

• Early in June, with Scott Crossfield at the controls, the X-15 passed its crucial first freeflight test, going through 5 min of gliding maneuvers after release at an altitude of 7 miles from a B-52 aircraft. Crossfield landed the sleek ship perfectly on Rosamond Dry Lake near Edwards AFB.

• A developmental version of the second-stage Centaur liquid-hydrogen engine will be test-fired for the first time this fall on stands being constructed at Pratt & Whitney's West Palm Beach, Fla., facility.

• Project Pluto, the joint USAF-AEC program for a nuclear ramjet engine, received a boost with the awarding of a prime contract for further development work to Marquardt's Astro Div. Major tests of nuclear components for Pluto will be conducted at AEC facilities now under construction at Jackass Flats, Nev.

• Storable liquid-propellant versions of Titan and Atlas are under study.

• Following on an earlier letter contract, the Air Force awarded Hercules Powder a $15,326,000 contract for development of a Minuteman third-stage solid engine. Hercules will do most of the development at its Bacchus, Utah, facility, with some supporting work from its Kenvil, N.J., propellant plant.

• Astrodyne received a $2 million Air Force contract for development of cast solid propellants and testing of large-scale motors.

• Under Air Force contract, IBM is developing a transistorized computer for underground Sage centers. The new computer will be about 10 per cent the size of the present one yet have about seven times the computational capacity.

• A steel gantry more than 300 ft high will be built at either Redstone or Cape Canaveral to erect and service the Saturn space vehicle.

MATERIALS

• In conjunction with Nuclear Metals Inc. of Concord, Mass., the Martin Co. has fabricated beryllium sheet and used it to construct basic

airframe. Excellent sheet properties have been obtained by controlling crystal size and orientation. Martin engineers point out that major limitations to beryllium usage remain; the sheet can be formed or bent only within a finely defined band of hot-forming temperatures and can as yet only be joined with fasteners, and not fusion-welded. Martin claims that beryllium extrusions, forgings, and rolled sheet all continue to show crystal orientation leading to the metal's familiar brittleness.

• Brush Beryllium will fabricate the 6-ft-diam beryllium heat shield for the Mercury capsule from a block 72 in. in diam and 5 in. thick. The block will be forged, through Brush's patented QMV sintering process, in a 50,000-ton press operated by the Aluminum Co. of America under the USAF heavy-press program.

• At the ARS Semi-Annual meeting in San Diego, Wyman-Gordon exhibited a closed-die-forged, nickle-base-alloy turbine wheel 45 in. in diam and weighing 520 lb when machined. For use in the temperature range 1500–1800 F, the wheel, showing the same structural integrity as smaller components, opens the possibility of higher temperature operation for large jet and liquid-rocket engines.

• Lockheed's Georgia Div. received a $525,000 WADC contract for a two-year's study of four newly developed titanium alloys, which will be supplied by Mallory-Sharon, Crucible Steel, and Titanium Metals under USAF programs.

• Astrodyne, following on its work with the Teal motor, described in the June 1958, ASTRONAUTICS, has developed a cheap rubber-asbestos motor case insulation for long-burning, high-performance solid rockets.

• A 14-man committee appointed by NAS-National Research Council will inquire into means to accelerate U.S. materials research and development to meet the needs of defense and industrial programs.

INDUSTRY

• The potential Thiokol-Marquardt merger cooled off, evidently owing to difficulties in agreeing on an exchange of stock. Thiokol has continued merger discussions with several other companies . . . Marquardt's Cooper Development Corp. received the annual Space Industries Small-Business Award at the National Missile Industry Conference . . . Texaco acquired Experiment Inc. through an exchange of stock . . . Airborne Instruments Laboratory Div. of Cutler-Hammer purchased the Fairchild Engine Div. plant at Deer Park, New York, with title transfer scheduled for Sept. 30 . . . All American Engineering of Wilmington, Del., formed an astronautics division to consolidate its aerospace research and development, including work on interplanetary navigational systems . . . Liquid hydrogen is being produced in large quantities in plants planned by ARDC several years ago. For some time now, Stearns-Rogers has operated a plant in Bakersfield, Calif., and Air Products one in Painesville, Ohio. Air Products recently built and started operation of a large plant for the Air Force in Palm Beach County, near Pratt & Whitney's Centaur-development facility.

EDUCATION

• With the support of the local section, a group of New York ARS student members have formed the New York Student Council to serve as an educational aid to the some 300 student members in the metropolitan area.

• Donald Simkin, head of Marquardt's combustion development group, was selected for the second year to give UCLA's two-week summer session, Aug. 17–28, on the thermochemistry of rocket combustion. The UCLA summer session will offer several courses on rocketry and astronautics, as mentioned previously here.

• The ARS Southern California section will spend up to $500 to provide ASTRONAUTICS to high schools and junior colleges in the chapter's area.

• Constatine Generales, roommate of Wernher von Braun during their college days in Zurich, surprised a class in the history of medicine at New York Medical College by lecturing on space medicine, and predicting that courses, and even departments, of space medicine will be introduced into many medical schools before long.

• The Soviet Exhibition of Science, Technology, and Culture, which opened in New York's Coliseum, June 30, includes full-scale models of the sputniks and a panorama on the exploration of space.

RUSSIA

• Repeated references appear in the Russian literature to a carefully planned, systematic program for space exploration (see page 43), and to a propulsion system in being capable of placing a payload of several thousand pounds on the moon. Rumors in Washington have it that there is evidence of continued flight-testing of large, high-altitude vehicles in the Soviet Union. The import—another major Russian space venture in the offing . . . I. S. Shklovskiy concludes that none of the "natural processes" can explain either the origin of the Martian moons, Phobos and Deimos, or peculiarities in the motion of Phobos, which he predicts will fall on Mars in 15 million years. He believes that it is not impossible that these moons are artificial satellites created by intelligent life early in Mar's history. An instrumented probe, he said, might provide clues to the nature of Mars in the next few years . . . A radio telescope for receiving 3-cm waves from the layers of the sun's corona has been built at the Crimean Scientific Station of the Lebedev Physics Institute. The 30-m-diam mirror for the telescope is a paraboloid made of concrete set into the earth and zinc coated. Viktor Vitkevich, director of the station, says he has succeeded in detecting the "hot" portions of the corona and in obtaining a picture of the distribution of the temperatures, densities, and other characteristics of the sun's outer regions . . . Members of the Institute of Atmospheric Physics in Moscow are making extensive studies of the night sky and aurorae with a "patrol spectrograph" . . . Instead of blasting satellites into space to study the upper atmosphere, one Soviet scientist has proposed construction of an "aerostatic tower" reaching to an altitude of 160 km. Supported by gas pressure, the tower would resemble an upside-down funnel. Its circular base would measure 100 km in diam, its top 390 m.

GREAT BRITAIN

• Over the past several months, Great Britain has made decisions which in effect give it a satellite research program. Although it will develop its own satellite instruments, Britain might at first rely on U.S. launching vehicles through the facilities of COSPAR, the Committee on Space Research of the International Council of Scientific Unions. The program will not interfere with the Blue Streak development, but it will include design studies for the eventual use of this ballistic missile's propulsion

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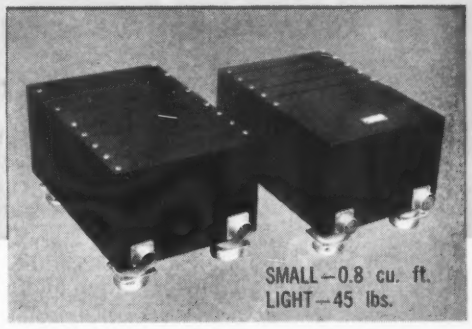

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system as a satellite booster . . . Built by Rolls-Royce, the Blue Streak engine incorporates design principles evolved by Rocketdyne, with which Rolls-Royce has a licensing agreement. The Blue Streak differs from the Rocketdyne MB-2 chiefly in having a different turbopump arrangement and control system and direct divergence of the nozzle . . . The Smithsonian optical tracking station at Woomera successfully photographed Vanguard I at its apogee of nearly 2500 miles with a Baker-Nunn camera.

EUROPE

• NATO countries continue to build their missile might. The 1st Danish Nike Battalion, in training at Fort Bliss, Tex., received a complete set of Nike equipment recently; equipment for a Nike installation began arriving in Italy; the first conventional Honest John's were delivered to West German army units; the Greek government indicated that Greece may soon receive Nike's and Honest John's; and Italian, German, and French firms are making arrangements to manufacture Hawk and Sidewinder in Europe.

JAPAN

• The 1959 Symposium on Rockets and Astronautics held by the Japanese Rocket Society at the University Club in Tokyo in June featured sessions on propellants, vehicles, biology, instrumentation, space science, satellite and space probes, and rocket motors, with as many as 10 papers to a session common. Ernst Stuhlinger and J. E. Masterson chaired the two sessions on space science.

• Other Americans in attendance, and presenting papers, were J. E. Froelich of JPL, Angelo Miele of Purdue Univ., Cremer Muller of Solar Aircraft, Lt. Col. C. G. Strathy of ARDC, E. W. Wahl of AFCRC, and Frank Kasala of Pacific Electronic Co. The meeting was replete with informal get-together party, banquet, film evening, and an excursion to the rocket test plant at Kawagoe.

• There does not appear much likelihood that Japan will attempt any early production of Sidewinder or Hawk missiles; but the Japanese Defense Agency is hoping to set up a corps trained to handle ground-to-air missiles which can employ nuclear warheads.

what is entropy?

Heat lost except at absolute zero?

A measure of disorder?

A statistical probability of state?

The gradient of a scalar?

Macrocosmic phenomenon or microcosmic, too?

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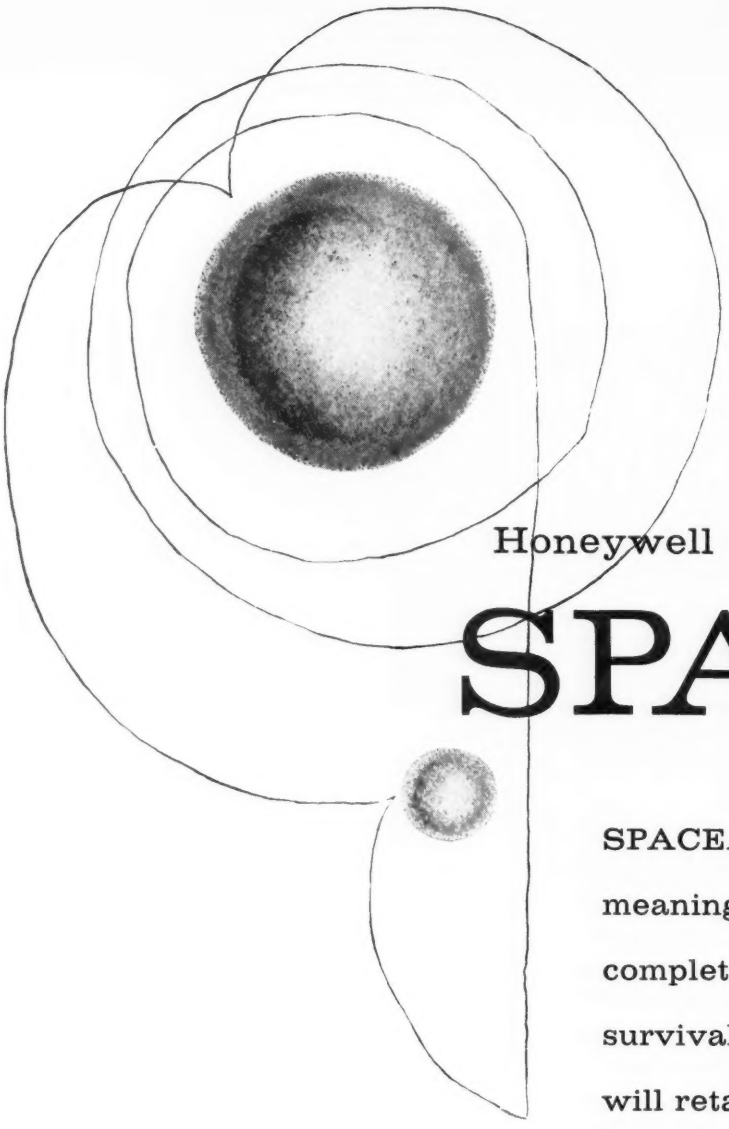

Honeywell calls it

SPACEA

SPACEABILITY is a new term meaning the capability to completely equip man for survival in space. While he will retain the ability to exercise his judgement with manual controls, man's welfare in space will depend largely on automatic control of his navigation, flight and power—in fact, his total environment, including food, oxygen and waste disposal.

There are three areas indispensable to space operations: (1) motion control and navigation for vehicles of flight, including inertial systems; (2) environmental control for human activity; and (3) instrumentation and data processing both on the ground and in the air.

Recognition of Honeywell leadership in all three areas is exemplified by the fact that Honeywell controls are going into almost all space vehicles presently planned.

ABILITY

This Honeywell capability is benefiting the following projects, some of which have already been completed:

- Providing complete guidance and flight control system for Project Scout, the NASA launching vehicle for orbital and probe flights of instrumentation satellites.
- Developing navigation and guidance system for the proposed Martin version of Dyna-Soar, the Air Force pilot-controlled semi-orbital vehicle.
- Developing and producing an advanced space cabin environment simulator for the Air Force School of Aviation Medicine.
- Supplying orbital injection guidance reference systems for Project Vanguard's launching of satellites into predetermined orbits.
- Developing and producing attitude control for both orbiting and re-entry versions of project Mercury, the NASA manned Satellite program.
- Developing and producing attitude stabilization systems for vehicles used in re-entry test phases of Project Mercury.
- Human engineering studies and instrumentation development for pilot orientation in space flight for Project Mercury.

Corporate capability—With a notable background in missile and space systems management, as well as in the design, development and production of systems and components, Honeywell is fully qualified for work on all phases of prime missile and space systems.

Human engineering in relation to space flight is being studied by an entire project team at the Military Products Group's aeronautical facility in Minneapolis. The group is made up of specialists in anthropology, anthropometry, bio-chemistry, bio-physics, psychology and psycho-servo analysis. Their goal: optimum integration of man into a complex control system, which involves problems such as efficiently dividing labor between manual and automatic computation equipment.

Honeywell organization makes available to space projects unique capabilities and experience. These include Industrial Instrumentation, Computing and Recording complex; the services of environmental experts in the Temperature Controls Group; and associated members of the Military Products Group: Ordnance, Aeronautical, Boston, and Missile Equipment Divisions. The Corporate Research Center works closely with all groups.

Areas of interest and activity at Honeywell for space projects include the following:

Inertial guidance and navigation systems, gyros, stable platforms, accelerometers, computers, air data systems, ballistic trajectory control systems, horizon scanners, fix takers, reaction jets, control valves.

Other areas are flight data sensing and display systems, telemetry and recording systems, data reduction systems, pressure and temperature sensors, analog-digital and digital-analog converters, atmosphere composition control systems, temperature control systems, pressure control systems and recording devices.

If you have a problem that requires outstanding capability in control for space projects, call on Honeywell. For information write Honeywell, Minneapolis 8, Minn.

Honeywell

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For the record

The month's news in review

May 1—NASA cancels Venus probes scheduled for June.

—NASA names its new space center at Greenbelt, Md., the Goddard Space Flight Center.

May 2—AF says operational Atlas will be ready in July.

May 5—AF Titan drops first stage in successful test.

May 6—NASA awards Convair-Astronautics $33.5 million Vega contract.

—House space committee authorizes NASA $485,250,000 for fiscal 1960.

—Army fires Jupiter 1500 miles.

—AF Snark completes 5000-mile test flight.

May 10—House space committee report says U.S. hopes to have worldwide satellite communications network operating by 1963.

May 11—AF discloses that liquid hydrogen rocket fuel is being produced on large-scale by Air Products Inc. and Stearns-Roger Mfg. Co.

May 12—Prime Minister Macmillan officially announces England's plans for space research program, to start with development of an earth satellite.

May 13—Army receives first of eight Rocketdyne engines for Saturn development.

May 14—Army says Jupiter is ready for operational use.

—Jodrell Bank sends intercontinental message to AF Cambridge Research Center, using the moon as a reflector.

May 15—DOD and AEC reverse themselves, agree to recommend development of a prototype nuclear plane.

—AF Chief Scientist Joseph V. Charyk is nominated as AF Asst. Secy., succeeding Richard C. Horner, now NASA associate administrator.

May 17—Navy-devised snare catches dummy Polaris missiles in mid-air so they can be re-used.

May 18—Raytheon proposes sky station that hovers at end of electromagnetic "extension cord," for which it expects AF study contract.

—Atlas carrying operational-type warhead blows up.

—Navy Polaris fizzles in flight.

—AF releases photos recently made from Thor nose cone at 300 miles altitude.

May 20—House okays $480,500,000 for NASA for fiscal 1960—$70 million for Project Mercury and $333 million for R&D.

May 21—AF recovers Thor-Able nose cone after 6000-mile trip down the Atlantic.

—NASA says it plans 47 space shots, including 11 lunar and interplanetary probes, within next 2 1/2 years.

May 22—AF reveals it has proposed to Joint Chiefs of Staff a nuclear command which will include new missile-hurling subs.

May 23—Report by President's Science Advisory Committee recommends doubling of education fund.

May 26—DOD tells Congress it has no long-range program for space research, puts Herbert F. York, director of research and engineering, in charge of its military space program.

—*Vestnik*, official organ of Soviet Academy of Sciences, says the academy has approved a decentralized system of administering and planning Soviet scientific research.

May 27—NSF asks Senate to restore House cut in funds for basic research.

—Detlev W. Bronk, president of NAS-NRC, announces formation of a new Committee on the Scope and Conduct of Materials Research.

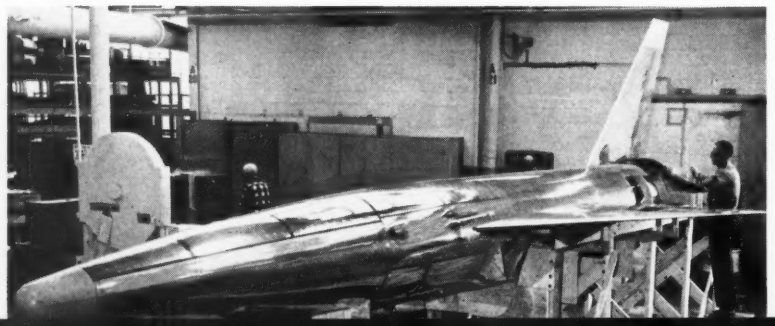
May 28—NASA discloses that monkeys Able and Baker, placed in a Jupiter nose cone, were recovered alive after being rocketed 300 miles into space from Cape Canaveral.

—James R. Killian Jr., President's special assistant for science and technology, resigns to return to MIT. George Bogdan Kistiakowsky, professor of chemistry at Harvard Univ., succeeds Dr. Killian.

—House space committee discloses Army has been working on a new airplane resembling a saucer.

May 31—NASA says it plans a transcontinental radio link between New Jersey and California by bouncing radio signals off a balloon orbiting in space.

Swallow Mockup



Shown for the first time in full-scale mockup, the all-weather jet-propelled reconnaissance drone, Swallow, being developed by Republic Aviation for the Army Signal Corps in a $30 million program, will be made in test versions this year. The drone will employ infrared, radar, photographic, and other devices for reconnaissance.

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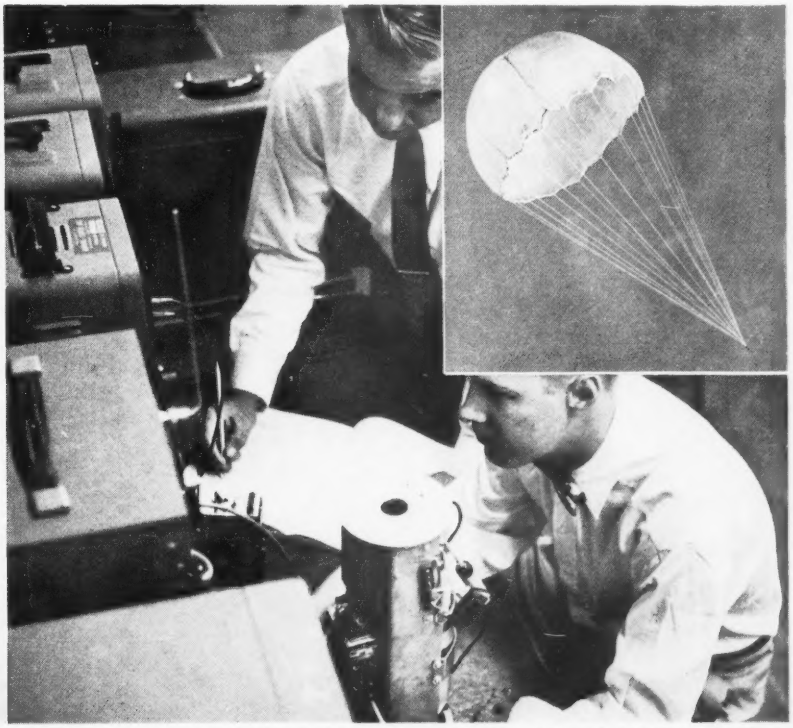

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NUMBER THREE IN A SERIES... TEMPERATURE

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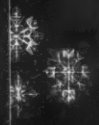
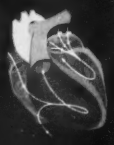


FLOW



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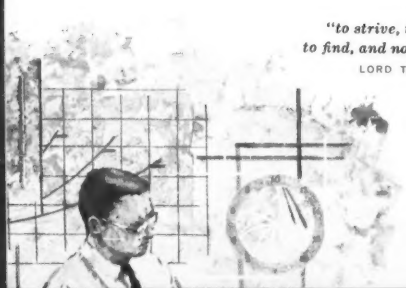

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COVER: *"Radiation," a photogram by the talented photography team of Erich Locker and Gladys Washburn, utilizes moving lights to provide a studio impression of the patterns formed by various types of radiation in space.*

Astronautics

JULY 1959

Basic Research

The sober merchants of Pisa must have shaken their heads at the sight of dignified scholars earnestly dropping little weights out of the top of the famous leaning tower. Could this be some strange wager they were settling? Few engineering calculations could be made today without reference to the basic laws of gravitation deduced from simple experiments with falling rocks and feathers in a vacuum, accomplished on a dime-store budget with high-school talent and the audacity to seek universal explanations.

Dawn on Long Island is disturbed by an erratic, sputtering rocket flaming briefly in the sky as irate policemen chase the perpetrators of the pyrotechnics out of the vacant lot where the launching took place. Could these grown men playing with rockets at dawn be anarchists up to no good? From such experiments, Robert H. Goddard derived the basic equations of reaction propulsion for space missiles. He sought basic principles without which applied developments could never begin. Today, the universal laws of gravitation can be verified in the near vacuum of space by means of missiles derived from Dr. Goddard's basic research.

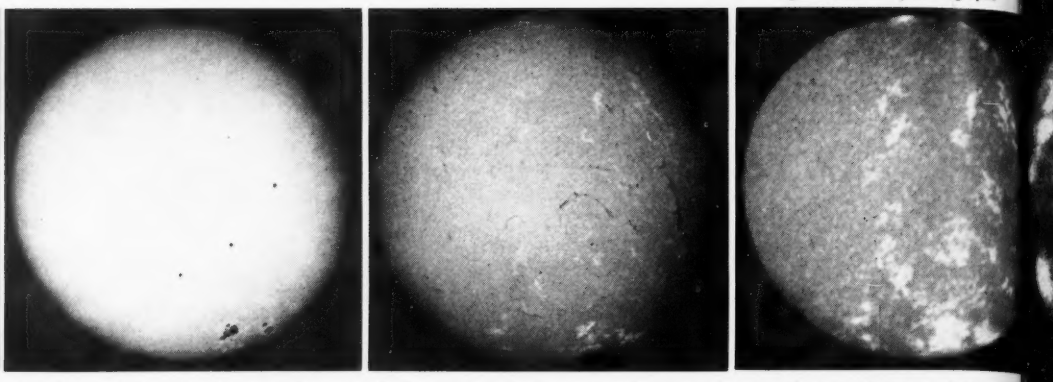
The exploitation of the frontiers of space, the massive growth of missile technology, the pressure to perfect applied engineering design should not extinguish curiosity and intuitive wonder concerning universal abstractions. Intellectual courage of a high order is required to leave the narrow channels of specialization, the rational justification of applied objectives that can be attained with proved certainty, for the precarious adventures of basic research with no assurance of positive results, no tangible product that cost accounting can justify.

Even more courage is needed to live with a humiliating awareness of ignorance while groping awkwardly for elusive truth in the outer darkness beyond the reassuring certainties of established fact, constantly exposed to suspicion and ridicule from those who frown on unconventional thinking. For such minds, the only dogma is doubt; the only credo, the open mind; the everlasting reward, the creative joy of discovery.

That the whole scientific progress of civilization depends on guidance from basic research was recognized by the more than 500 leading scientists and educators who attended the Basic Research Symposium in New York in May. For, in the words of President Eisenhower, "Basic science . . . represents the frontier where exploration and discovery begin. Moreover, achievements in basic research and new knowledge, adding as they do to man's fundamental understanding, have a quality of universality that goes beyond any limited or local application, and eventually benefits all mankind."

John P. Stapp
President, AMERICAN ROCKET SOCIETY

Official U.S. Navy Photographs



The three photos of the sun above and the one opposite were taken simultaneously March 13 in different spectra: From left, white light, Hydrogen-α, Calcium-K, and—for the first time—Lyman-α. The rocketborne camera shown on the opposite page took the Lyman-α photo.

The sun and the upper atmosphere

Rocket astronomy, adding to our knowledge of the solar spectrum, has begun to define the enormous role played by manifold solar radiations in the earth's atmosphere and in interplanetary space

By Herbert Friedman

U.S. NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.

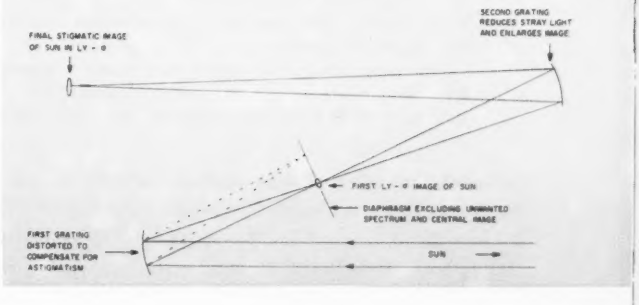
Herbert Friedman is supervisor of NRL's Atmosphere and Astrophysics Div., and formerly headed its Electron Optics Branch for a number of years. Actively engaged in upper-atmosphere rocket research since 1949, particularly in the field of solar-terrestrial relationships, he was in charge of NRL's solar flare rocket experiments at San Nicolas Island, played an active role in the instrumentation of Vanguard, and was a member of the working group on internal instrumentation for the IGY Technical Panel on Earth Satellites. Dr. Friedman recently received the Distinguished Civilian Service Award for development of radiation-detection devices and for important research in astronomy and astrophysics, including pioneering work in rocket astronomy.

BECAUSE of its enormous influence throughout the atmosphere, the sun has been the primary object of rocket astronomy since inception of this study some dozen years ago. In the uppermost regions, ultraviolet and X-rays create the mantle of electrified air known as the ionosphere. When the sun is active, it showers storms of ionized particles upon the atmosphere, creating huge electrical currents that distort the earth's magnetic field and produce the brilliant auroras.

One of the primary purposes of studying the sun is to relate solar weather, as observed with all the techniques of astronomy, to ionospheric and tropospheric weather. The sun is a dynamic complex of sunspot magnetic fields, plages, spicules, prominences, flares, and hot spots or condensations in the corona. Although the steady output of visible light in the sun suggests great stability, every technique for observing the solar surface in greater detail or in specific wavelengths shows that its surface is anything but quiescent.

Sunspots are often visible to the naked eye and the numbers wax and wane with an 11-year rhythm. Associated with these sunspots are localized magnetic fields more than 10,000 times as intense as the magnetic field of the earth and at times extending over a billion square miles. Powerful telescopes reveal a continually changing pattern of turbulence or granulation covering the entire disk. Fountains of hot gas called spicules surge up 1000 miles high above the granules and subside in a matter of minutes. Clouds of scarlet

Lyman-α solar disk camera, diagramed below, and a spectrograph rode in the special instrument package of the Aerobee-Hi, above, to the upper reaches of the atmosphere to take the first photo of the sun in Lyman-α. Two-axis rotation permits instruments to follow the sun despite rocket spin and yaw.


FINAL STIGMATIC IMAGE OF SUN IN LY - α
SECOND GRATING REDUCES STRAY LIGHT AND ENLARGES IMAGE
FIRST LY - α IMAGE OF SUN
DIAPHRAGM EXCLUDING UNWANTED SPECTRUM AND CENTRAL IMAGE
FIRST GRATING DISTORTED TO COMPENSATE FOR ASTIGMATISM
SUN

vapor, called prominences, erupt to heights of 50,000 miles and swirl off into space. At times, flashes of intensely brilliant radiation (solar flares) burst forth in the neighborhood of sunspots.

Rocket astronomy has shown that when the sun is particularly active both its ultraviolet and X-ray emissions increase. These are the radiations that affect the ionosphere, sometimes improving its radio mirror properties, at other times causing it to absorb radio waves and produce shortwave fadeouts. The total energy radiated in X-rays or ultraviolet light, however, is only a very small portion, measured in thousandths of a per cent, of the total energy output of the sun. The energy thrown off the sun in the form of gas clouds may be a thousand times as great as the short wavelength ultraviolet and X-ray emissions, so that it seems more likely that any relationship between solar weather and tropospheric weather is tied up with the transfer of particles from sun to earth, rather than electromagnetic radiations.

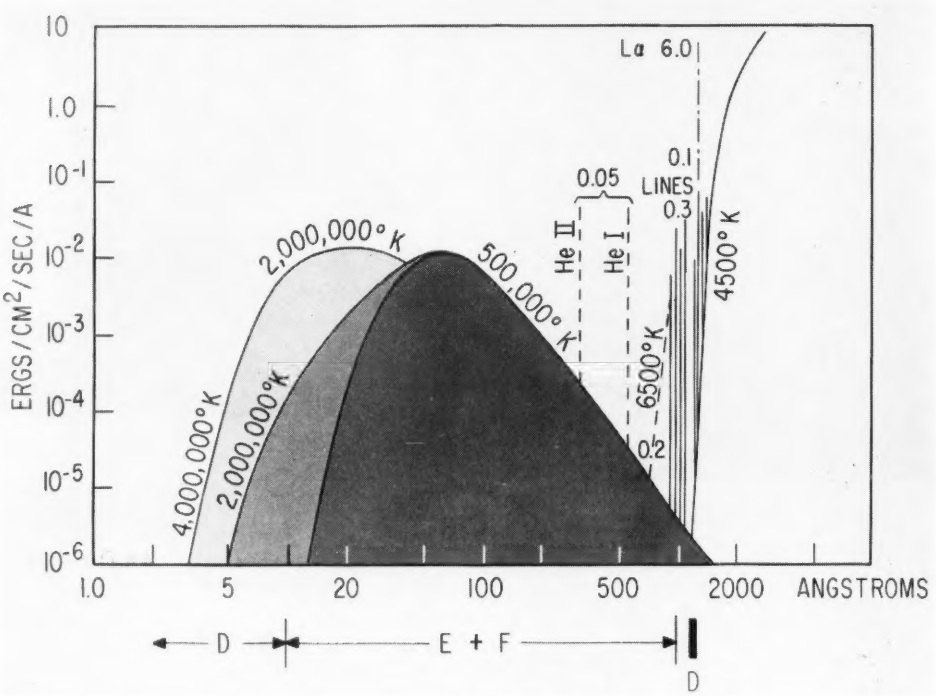
V-2 Played Important Role

Barely a dozen years ago, the short wavelength limit of observations of electromagnetic radiations from space was 2850 Å. All shorter wavelengths are absorbed by atmospheric gases—ozone, oxygen, and nitrogen. Early attempts to see beyond 2850 Å in the ultraviolet were made from mountaintop observatories and from balloons. In 1934, a spectrograph was flown to 30 km in a balloon, but even that height was not adequate. Not until October 10, 1946, when NRL scientists sent a spectrograph aloft in a V-2 rocket, was our knowledge of the solar spectrum extended into that region of the ultraviolet absorbed by ozone before it can reach the ground.

Since then, many successful spectrograms have been obtained with the aid of rockets by NRL, AFCRC, and the Univ. of Colorado; and, within the past year, almost the entire range of electromagnetic radiations has been photographed down to the X-ray limit. With the aid of photoelectric detectors in rockets, the interaction of the ultraviolet and X-ray spectrum with the atmosphere has been mapped out in height from the ozonosphere to the maximum of the ionosphere.

How does our present knowledge of the solar spectrum as obtained from rockets compare with ideas of 20 years ago? The spectrum of the visible sun encompasses a continuum of rainbow colors and is striated with dark Fraunhofer absorption lines. The continuous emission in the visible range resembles that of a 6000-K black body. We used to believe that it would still resemble a 6000-K source in the ultraviolet, but rocket measurements reveal

The Solar Spectrum as Measured from Rockets

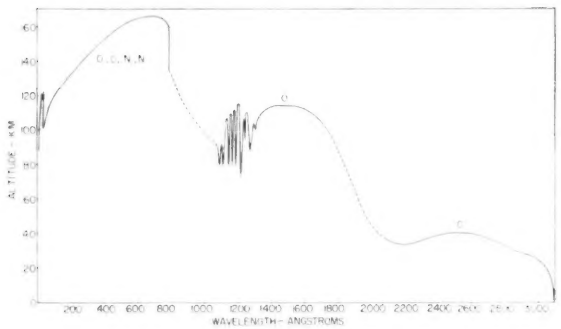


X-rays from a quiet sun have a distribution characteristic of a 500,000 K coronal temperature. Local condensations in the corona reach temperatures of 2,000,000 K and emit shorter wavelength X-rays. During a solar flare, the active region may reach temperatures as high as 10,000,000 K. The portion marked 4,000,000 K was observed during a small flare. In the ultraviolet, the continuum emission is very weak, and most of the energy is carried in a few strong lines, such as He II (304 Å) and Lyman-α (1216 Å).

the sun to be orders of magnitude weaker in its continuum as the wavelength decreases toward 1000 Å.

Throughout the 1000–2000 Å range, the primary atmospheric absorber is molecular oxygen, which is dissociated into atomic oxygen by the direct action of sunlight. Whereas a 6000-K ultraviolet sun would produce essentially complete dissociation near 100 km, at the base of the E-region of the ionosphere, the weaker sunlight measured with rockets never succeeds in completely dissociating oxygen even at a height of 200 km. We thus discover molecular oxygen as high as the F-region and this oxygen has important consequences in the formation of the higher ionosphere.

Penetration of the Atmosphere by Solar X-rays and Ultraviolet

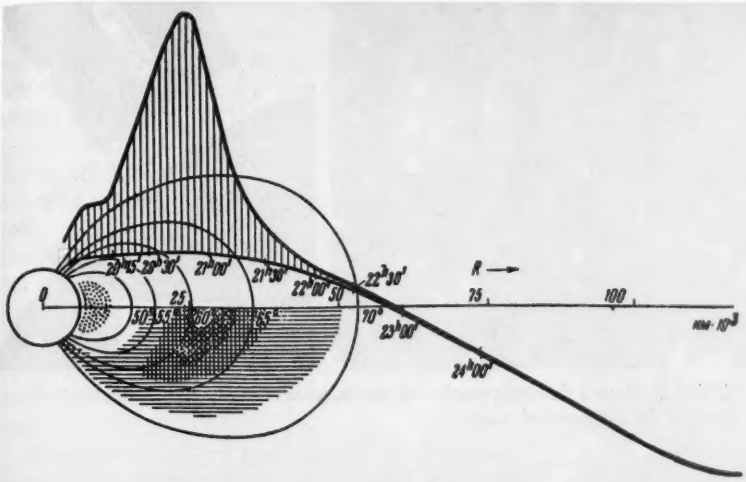


Note: At the indicated level, the fraction 1/e (natural log base) of the incident flux remains. Absorbing molecules are indicated at the appropriate wavelengths.

Below 1500 Å, the continuum intensity becomes almost negligible, and bright lines begin to appear in the spectrum. Lyman-α, the characteristic resonance emission of hydrogen atoms at 1216 Å, stands out as the most prominent emission line in the solar spectrum. Until recently, there remained a great gap in our knowledge of the solar spectrum between Lyman-α and the X-ray region, but during the IGY remarkable progress was made in the spectroscopy of this region. In the entire range, between Lyman-α and the X-ray end of the scale, over 100 emission lines have been photographed. There appears to be more energy in the single wavelength emitted by ionized helium at 304 Å than in all of the rest of this region combined.

Measurements of X-ray emission have been made primarily with photon counters and ionization chambers. The quiet-sun distribution resembles a thermal source at a tem- (CONTINUED ON PAGE 55)

Trajectory of Mechta in Geomagnetic Coordinates, Showing Radiation Pattern



Note: Along the trajectory are shown flight time (Moscow) and intensity (vertical lines extending to the trajectory). The drawing includes magnetic force lines intersecting the earth's surface at geomagnetic latitudes of 50, 55, 60, 65, and 70 deg. The magnetic field is taken as the dipole field with geomagnetic pole coordinates 78.5 deg N and 69 deg W. The internal zone is shown by dots, the external by hatching. Intensity distribution in the second zone is shown qualitatively by hatching density.

Mechta radiation data

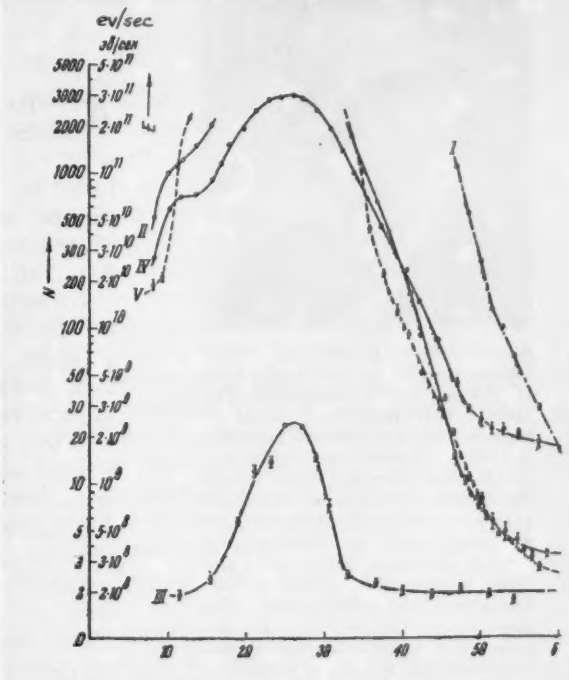
Russia's heavily instrumented lunar probe has yielded quantitative data on cislunar corpuscular radiation, as well as the Great Radiation Belt

By S. N. Vernov, A. Ye. Chudakov, P. V. Vakulov, and Yu. I. Logachev

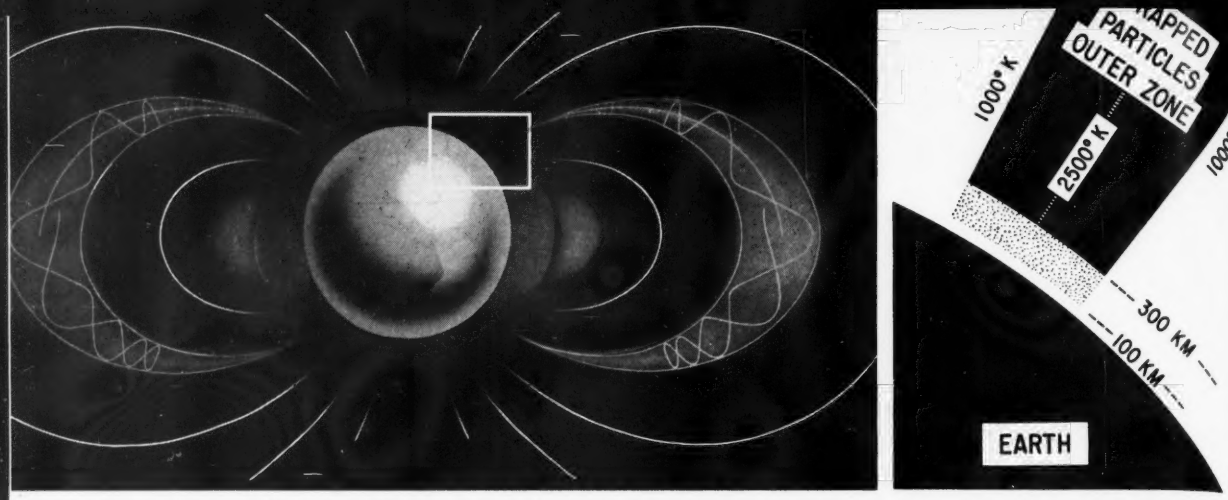
THE COSMIC rocket (Mechta) launched in the direction of the moon on Jan. 2, 1959, was provided with equipment for recording cosmic rays and terrestrial corpuscular emission. The latter is understood to consist of streams of fast charged particles at high altitudes, for which the magnetic field of the earth provides a so-called "magnetic trap," causing the emission to have a relatively high intensity. The equipment installed on the cosmic rocket was aimed at providing, insofar as possible, data related to the two specific questions. Two Geiger counters and two scintillation counters detected particles. The Geiger counters had 1 by 5 cm and 1.8 by 10 cm dimensions; the walls were made of stainless steel 0.1 mm thick.

The first scintillation counter was further development of a device used by us on Sputnik III. The detector consists of a cylindrical crystal of sodium iodide of 39 by 40 mm size. Measurements were carried out of phenomena with energy thresholds of I—45 kev; II—450 kev; III—4.5 mev; and IV—the total ionization produced in the crystal. To avoid nonlinear distortions, the ionization determination was carried out by measuring not the anode current but the current of one of (CONTINUED ON PAGE 86)

Relationship of Intensity to Altitude



Note: R—Distance to earth's center; I, II, III—counting tempo with threshold of 45 kev, 450 kev, and 4.5 mev, respectively; counting tempo refers to unit of cross-sectional area of counting crystal (19 cm²); IV—total ionization (full energy liberation in crystal per second); V—Geiger counter readings.



General form of the Great Radiation Belt (left). Frame demarks portion of the auroral zone for which heating effects were calculated. At right, model of heating in the auroral zone.

Density and temperature of the upper atmosphere

Analysis of IGY rocket and satellite data leads to the surprising picture of density in the auroral zone controlled by the Great Radiation Belt, and relatively independent of latitude outside this zone

Robert Jastrow is chief of NASA's Theoretical Division and is also head of NASA's Lunar Exploration Program. After receiving a Ph.D. in physics from the Univ. of Columbia in 1948, Dr. Jastrow spent a year as a postdoctoral fellow at Leiden Univ. in the Netherlands and a subsequent year as a member of the Institute for Advanced Study at Princeton, N.J. He was a research fellow and a professor of physics at the Univ. of California from 1950 to 1954, when he became a consultant to NRL. Dr. Jastrow joined NASA in his present position when the agency was formed.

By Robert Jastrow
NASA GODDARD SPACE FLIGHT CENTER, GREENBELT, MD.

AT THE beginning of the International Geophysical Year, the density and temperature of the upper atmosphere were relatively well known below 100 km, and known with less precision up to 200 km. Above 200 km the properties of the atmosphere could only be estimated by extrapolation from data at lower altitudes. These estimates were uncertain by factors of 100 at an altitude of 500 km and 10^4 at 1000 km.

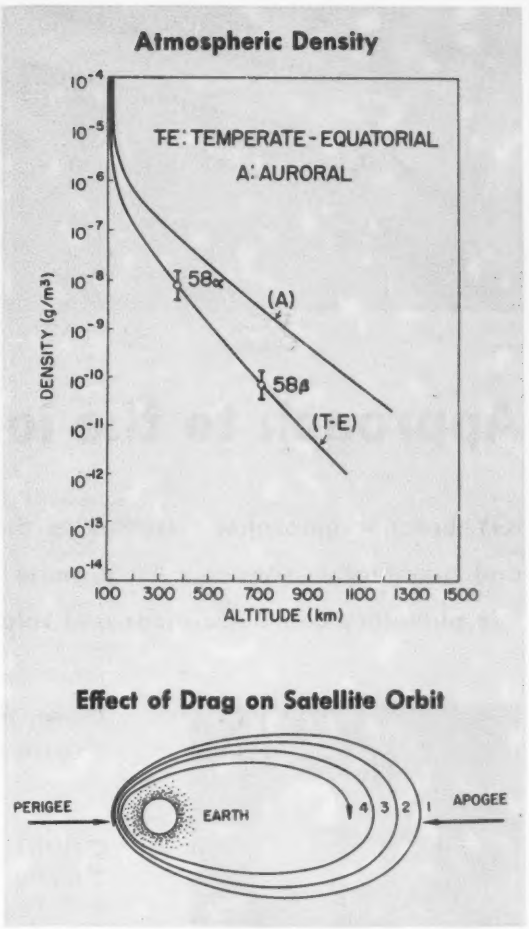
The ceiling on density measurements was lifted to 700 km by the first data from Vanguard I, which yielded values at that altitude with an uncertainty of a factor of 2. Other satellites before and after Vanguard I filled in the density curve at intermediate altitudes with the same precision. Analysis of these measurements, in combination with rocket data at lower altitudes, has revealed several interesting features which promise to broaden our understanding of upper atmospheric dynamics. For instance, there is evidence that the upper atmosphere in the auroral zone is controlled by the intensity of particles in the outer Van Allen belt, and has properties differing entirely from those of the atmosphere at temperate and equatorial latitudes.

The density of the atmosphere is determined from satellite tracking data by an indirect method, based on analysis of changes in the

satellite period of revolution. The change in the orbital period is a direct result of atmospheric drag, which causes the satellite to lose energy continuously during its lifetime. As the energy of the satellite decreases, it falls toward the center of the earth, reducing its average altitude, and therefore the time required to complete each circuit. Detailed calculations, based on the equations of satellite motion, determine the quantitative relation between the reduction in the period and the average air density in the orbit.

The figure at bottom right shows the effect of drag on the orbit. Drag at perigee decreases satellite altitude on the succeeding apogee, shortening the period.

Since density falls off very rapidly with increasing altitude, the average density in the orbit is heavily weighted by the contributions near perigee.



Strong Latitude Dependence Shown

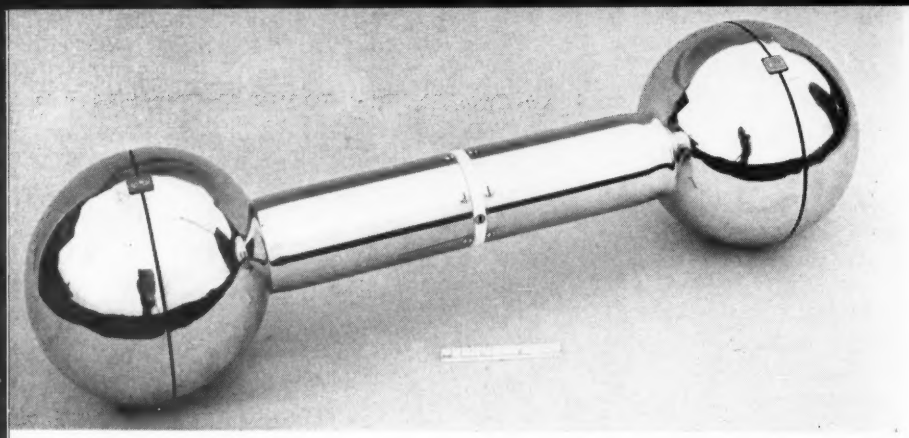
A strong latitude dependence is one of the most interesting characteristics of the density data obtained from rocket flights during the IGY. Measurements by LaGow, Townsend, and their collaborators at NRL indicate that at 200 km the summer daytime density at Arctic latitudes is six times greater than the corresponding density at temperate latitudes. LaGow has also found that density values in the Arctic Zone depend on the season and time of day. His data show that at an altitude of 200 km the northern atmosphere is two times heavier in the day than at night, and two times heavier in the summer than in winter.

It is not difficult to find a simple explanation for the diurnal, seasonal, and latitudinal variations. During the day, the sun heating the atmosphere probably causes an upward expansion, resulting in a large increase in density at high altitudes. The effect of solar exposure should be greater in summer than in winter, and most pronounced during the long day of the Arctic summer, in agreement with LaGow's observations.

Direct temperature measurements have not been made in the upper atmosphere. However, temperature can be determined indirectly from the altitude dependence of the density measurements with the aid of the formula: $d = d_o\, e^{-(h - h_o)/H}$. This formlua gives the relationship between the density (d) at altitude (h) and density (d_o) at altitude (h_o). The scale height (H) is obtained from this relationship: $H = k\,T/\bar{M}g$, where k is Boltzmann's constant, T and $\bar{M}$ are, respectively, the temperature and molecular weight of the atmosphere, and g is the acceleration of gravity. The formula for density is valid if the collision mean free path in the atmosphere is less than H and the fractional change in temperature is small over a distance of H.

According to the formula for density, the temperature of the air is obtained directly from the slope of a logarithmic plot of density vs. altitude. By this method, LaGow and his collaborators determined atmospheric temperatures at altitudes between 150 and 200 km over the White Sands Missile Range in New Mexico and the Fort Churchill range in the Canadian auroral zone. They found that during a summer day the temperature of air in the auroral zone is approximately 2000 K, as compared with a relatively cool 1100 K over New Mexico.

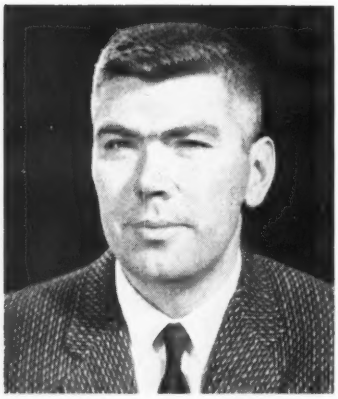
Satellite density data show large fluctuations in addition to systematic variations. These fluctuations are probably the result of atmospheric heating produced by streams of energetic particles and radiation from the sun. The surface of the sun boils and bubbles in a very active manner, occasionally emitting large gusts of plasma and radiation into the solar system. It has been discovered by Jacchia of the Harvard College (CONTINUED ON PAGE 108)



Instruments like this experimental Langmuir Probe will soon be giving direct measurements in the ionosphere.

Approach to the ionosphere

IGY brought ionospheric studies to the level of a systematic and quantitative science, with promise of solving problems of interplanetary communications and solar and cosmic processes



Warren W. Berning serves as chief of the Applied Physics Branch of the Ballistic Research Laboratories, Army Ordnance Corps. In this capacity, he has been active in upper-atmosphere research and has extensively studied ionospheric effects encountered in the radio tracking of high-altitude missiles. During the IGY, he directed the rocket research program of the Ordnance Corps in the measurement of electric currents and electron densities in the ionosphere and of water vapor at high altitudes. He served as a member of the IGY Technical Panel on Rocketry and its working group for rocket operations, and as Army representative to the Technical Panel on Earth Satellites and its working group on satellite ionospheric measurements. He is presently serving on the executive committee of the Rocket and Satellite Research Panel.

Warren W. Berning

BALLISTIC RESEARCH LABORATORIES, ABERDEEN PROVING GROUND, MD.

SHORTLY after the turn of the century, the scientific world was startled when Marconi transmitted wireless signals from Cornwall, England, to Newfoundland. Simple propagation of radio waves by diffraction beyond the horizon failed by a considerable margin to account for the strength of the received signals. Within two years of this remarkable event, a possible mechanism was postulated by Kennelly and Heaviside independently, when they suggested a conducting region in the upper atmosphere which could confine the radio waves in a rather shallow spherical duct concentric with the earth's surface.

Experimental verification of the Kennelly-Heaviside Layer, or the ionosphere, as the conductive region came to be known, waited until 1925, when Appleton and Barnett, using directive antennas, were able to separate signals arriving from the reflecting region and those propagated along the ground. These investigations showed the presence of several distinct regions of reflection, designated by Appleton the D-, E-, and F-Layers of the ionosphere. Within a year, Breit and Tuve employed the first pulse-delay radio sounder, and gave to the world a powerful tool for extensive quantitative studies of the ionosphere. Largely as a result of these contributions, a systematic study of the ionosphere became an important part of the research carried out in the Second International Polar Year (1932).

In the years following 1932, the vertical pulse-delay radio sounder was used to study the worldwide structure of the ionosphere, and in particular, the variations of charge density with altitude as functions of latitude, solar time and unusual fluctuations of the earth's magnetic field (magnetic storms). Through such studies, the morphol-

ogy of the ionosphere was developed empirically to the extent that very useful predictions of reliable radio communications could be made several months in advance.

Unfortunately, quantitative knowledge of the ionosphere based on measurements taken with ground equipment only suffers in several important respects. In the first place, the altitude at which the vertically transmitted radio wave is reflected from the ionosphere is inferred from the product of one-half the pulse delay (travel time of radio-pulse up and down) and the vacuum speed of light or radio waves. Unfortunately, the intervening ionosphere and atmosphere slow the pulse and distort the pulse waveform, so that the inferred height of reflection (virtual height) is considerably greater than the true altitude at which reflection takes place. The height error is quite large and is greatly increased when the variation of electron density with altitude is small.

A second limitation of the pulse-sounder lies in its inability to detect fine structure within the layers themselves. Appreciable radio reflections are obtained only from those regions having a positive gradient of electron density with altitude, so that "valleys" (negative gradients) in the ionospheric regions are not observed. Finally, and for the reason above, the nature of the ionosphere, above the F-Layer maximum electron density, is obscured from the view of groundbased equipment.

Limitations Recognized Early

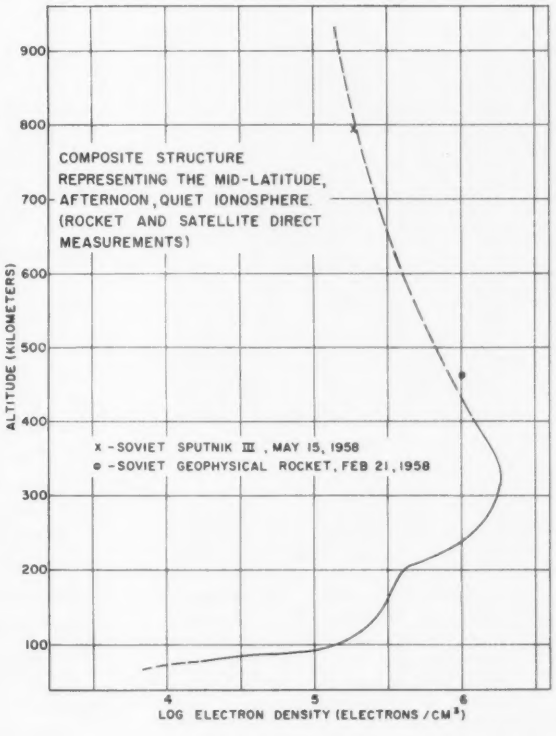
The obvious limitations of the ionospheric pulse-sounder were recognized quite early, and the desire expressed for direct measurements using rocket carriers. It was not until 1946, however, when the firing of captured V-2 rockets began in this country, that such a program could be initiated. In the early experiments, several techniques were employed, and it is significant perhaps that these same methods, somewhat modified and certainly improved, are in use today in both satellite and rocket high-altitude research programs. Of course, newer means for direct measurements in the ionosphere are being developed, and will be extensively used in future satellites, sounding rockets, and deep-space probes.

The advent of the IGY furnished a considerable impetus here and abroad to extend greatly our knowledge of fine structure of the ionosphere, and, in particular, to study the variations at different latitudes and for different solar conditions. With the help of the Canadian government, the U.S. National Committee for the IGY planned and implemented an extensive rocket research program at Fort Churchill, Canada. (CONTINUED ON PAGE 116)

Direct Ionosphere Exploratory Techniques

Method	Quantity Measured	Status	Vehicle
Phase/velocity comparisons	Electron density	Current	Primarily rocket
Faraday rotation	do	do	Rocket, satelite
Pulse retardation	do	do	Primarily rocket
Radio-dawn and radio-set	do	do	Satellite
Ion trap	Ion density, electron temperature	do	Primarily satellite
Scintillation measurements	Turbulence in the ionosphere	do	Primarily satellite
Langmuir Probe	Electron density, ion density, electron temperature	Immediate future	Rocket, satellite
Retarding-potential device	do	Future	Primarily satellite
Antenna impedance	do	do	Rocket, satellite
Top-side, sweep-frequency sounder	Electron density	do	Satellite

Profile of the Afternoon, Quiet Ionosphere in Mid-Latitudes



Measuring upper-air structure

IGY investigation of the larger structure of the 30–90 km region of the atmosphere introduced a variety of rocketborne instrumentation for making pressure, temperature, and density measurements

By Leslie M. Jones
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.

WHAT we call the structure of the upper atmosphere is generally understood to be described by the parameters, pressure, temperature, density, composition, and winds. A complete understanding of the composition, that is, of all particulate constituents, would be nearly the same thing as a complete understanding of the atmosphere, and in structure measurements a more limited idea of composition is usually adhered to. A simple, useful composition parameter is mean molecular weight.

A knowledge of mean molecular weight is essential in evaluating the relationships between pressure, temperature, and density. If, for example, one has measured the density (ρ_h) as a function of altitude (h), the temperature (T_h) may be calculated from

$$T_h = \frac{\int_o^h -\rho g dh}{\rho_h \; R/M} + \frac{\rho_o}{\rho_h} T_o$$

where g is the acceleration of gravity; ρ_o and T_o are known values at a starting altitude; R is the universal gas constant; and M is the molecular weight.

Leslie M. Jones is supervisor of the Univ. of Michigan's High-Altitude Research Laboratory. He received a B.S. in engineering physics from the Univ. of Michigan in 1940 and, after six years in industrial electronics, joined its program of upper-atmosphere research, which has occupied him since. He helped plan the rocket range at Fort Churchill, Canada, and was instrumental in introducing the Nike-Cajun rocket to the IGY program. His laboratory group has instrumentated 50 rockets of five different kinds for making upper-air structure measurements.

Ingenious Rocket Methods Devised

By means of rocketborne sample bottles and spectrometers, it has been established that the mean molecular weight of air is essentially the same from sea level to 90 km. With the aid of this fact, upper-air structure, excepting wind, may be investigated up to 90 km by measuring either density, pressure, or temperature and calculating the other two parameters by relationships of the kind given above. Various ingenious rocket methods have been devised since 1946 to measure P, T, and ρ.

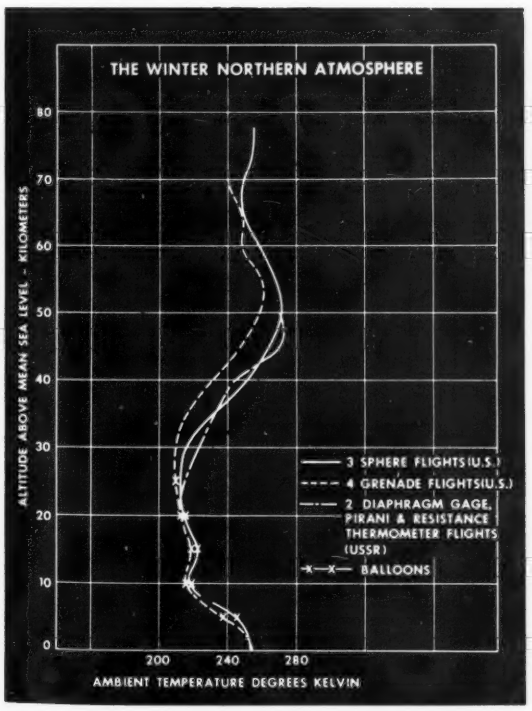
During the IGY, a major portion of U.S. sounding rockets carried structure experiments. The effort described here was concentrated in the altitude region from 30 to 90 km. The lower limit was set by the limitation of some of the methods and by the fact that balloon sondes cover altitudes below 30 km. The 90-km upper limit was set by the high cost of high-altitude rockets and, again, by the limitations of the measuring methods.

For instance, in addition to the uncertainty of mean molecular weight, only approximate methods of analysis are available in the

region where the mean free path is the same order of magnitude as the dimensions of the apparatus. At 90 km, the mean free path is about 3 cm. Variations of pressure-gauge and drag methods have nevertheless been used in the region from 100 to 250 km on rockets and satellites. Above 150 km, where the mean free path is 3 m, the aerodynamic analysis is more firmly established than in the "transition" region below. A complete interpretation of $PT\rho$ measurements, however, awaits more knowledge of composition.

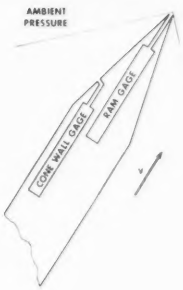
The IGY program of the Univ. of Michigan consisted of 31 rockets—13 Aerobee's and 18 Nike-Cajun's, equipped with three types of instruments for structure measurements.

N. W. Spencer, of the University's Space Physics Research Laboratory, in a series of 11 firings sponsored by AFCRC, used alphatron ionization gauges to measure ram and cone-wall pressures. Air was admitted to gauges from the surface of the cone through short tubes, as indicated in the figure at top right. Ions produced by a tritium beta source were accelerated to a collector electrode. The neutralizing electrons passed through very high resistances in the collector circuit as in conventional filament-type gauges. The resulting IR drop, a measure of the air density (or pressure at a known gauge temperature), was then telemetered to the ground. Automatic switching circuits changed the collector circuit resistors to accom- (CONTINUED ON PAGE 50)

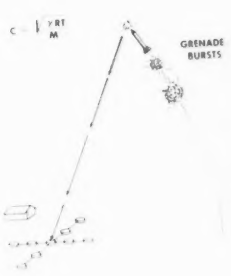


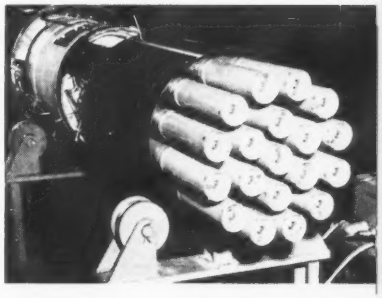
Rocket Instrumentation for the 39–90 Km Region

P-T-ρ BY PRESSURE MEASUREMENTS ON CONES



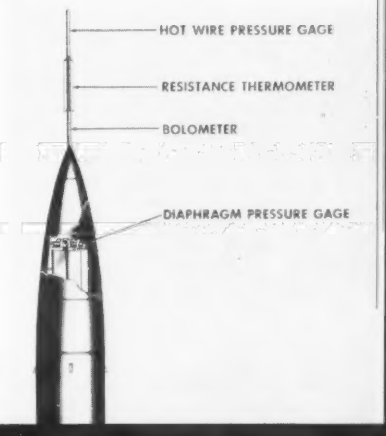
P-T-ρ AND WINDS BY GRENADES





P-T-ρ BY DRAG ON A SPHERE

P-T-ρ BY DIAPHRAGM GAUGE AND RESISTANCE THERMOMETER

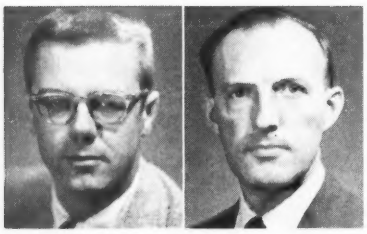


Positive ions in the ionosphere

Mass spectrometers, borne aloft by Aerobee-Hi's in IGY experiments, show that positive ions of mass 30^+, presumably nitric oxide, play an unsuspectedly large role in the control of the ionosphere

By Julian C. Holmes and Charles Y. Johnson

U.S. NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.



Holmes Johnson

Julian C. Holmes and Charles Y. Johnson are members of the Rocket Sonde Branch of the Naval Research Laboratory. Holmes, a 27-year-old physicist from Maine, received a bachelor's degree in physics from Bowdoin College (1952). He is presently doing part-time graduate work in physics at the Univ. of Maryland. Since joining NRL in 1952, he has been working in the fields of electronic countermeasures and ion composition of the ionosphere.

Johnson, 38-year-old native of the District of Columbia, graduated from the Univ. of Virginia (1942) with a bachelor's degree in electrical engineering. Since 1946, which marked the beginning of NRL upper-atmosphere research, his work has been concerned with cosmic rays and ion composition of the ionosphere. He is a member of the American Geophysical Union, American Physical Society, and Institute of Radio Engineers.

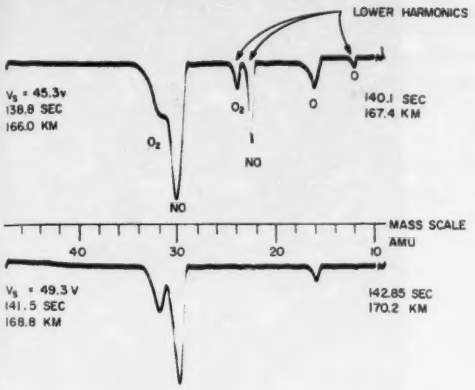
FOR ALMOST 200 years, man has been investigating manifestations of physical phenomena which take place in the earth's ionosphere. The northern lights and magnetic field variations have been longest under man's scrutiny. During the first years of the present century, with the beginning of successful long-distance radio communications, the existence of an electrically conductive region high in the earth's atmosphere was postulated by Kennelly and Heaviside. Their suspicions were confirmed in the early 1920's by scientists both in Great Britain and the U.S. who made measurements on radio waves reflected from the ionosphere. Since then, the ionosphere has been under almost constant surveillance of one kind or another. Concern for reliable communications, understandably, fathered much of this work.

But today, a more general interest in our ionosphere is being taken by chemists, physicists, and astronomers alike. Radio blackouts, sudden ionospheric disturbances, magnetic storms and day-to-day ionospheric parameters are now being studied not only for prediction purposes, but also to gain a solid understanding of ionospheric physics. This electrical upper atmosphere, while providing us with interesting evidence of its activities, actually shields us from much of the electromagnetic, and all of the corpuscular, radiation that is incident on our outer atmosphere.

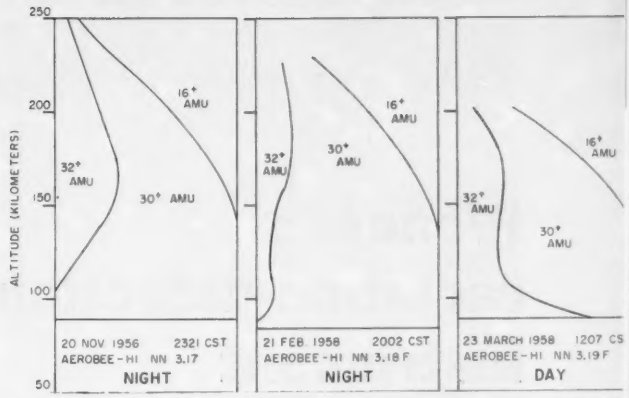
It is to this ionizing radiation that the ionosphere owes its existence, and it is the variation in this radiation that produces its activity. Ground observations of the ionosphere thus assume new significance, one being that of providing an indirect monitor of energy flow between the sun and earth.

Before the development of the high-altitude research rocket, groundbased observations on reflected radio waves were our main source of information. Rockets which carry instrumentation to measure ionospheric electron density have gathered sufficient data to correct a number of misconceptions concerning the interpretation of these ground recordings, with the result that we can now interpret them in terms of actual electron density profiles. The electrons, stripped from neutral molecules and atoms by the action of solar ultraviolet and X-radiation, leave behind their counterpart, the positive ion. The interaction of these ions with other atoms, molecules, and electrons constitutes the electrical chemistry of the ionosphere. The maintenance of our ionosphere at night, in the absence of incident solar energy, is partially de-

Positive-Ion Spectra



Altitude Distribution of Positive Ions



scribed in terms of this chemistry.

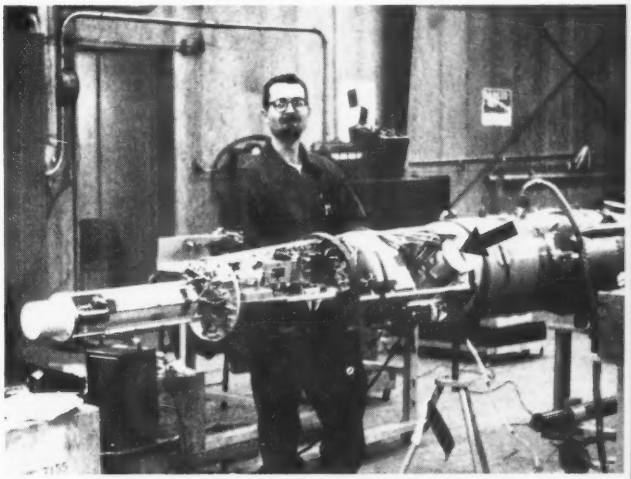
The collective motion of these ionized particles in the presence of electric fields may account for some of the time variations in the earth's magnetic field as measured at ground level. Evidence which strongly suggests such phenomena has been gathered by rocketborne magnetometers, which have measured sharp discontinuities in the ambient magnetic field at altitudes above 100 km in the vicinity of auroral activity.

NRL Developed Instrumentation

Basic to the understanding of these ionospheric phenomena is the determination of exactly what atoms, ions, and molecules are present in the ionosphere at various times of the day and night. It was for this purpose that the U.S. Naval Research Lab developed IGY rocket instrumentation that would simultaneously measure the upper atmosphere's ambient neutral gas, positive-ion, and negative-ion composition.

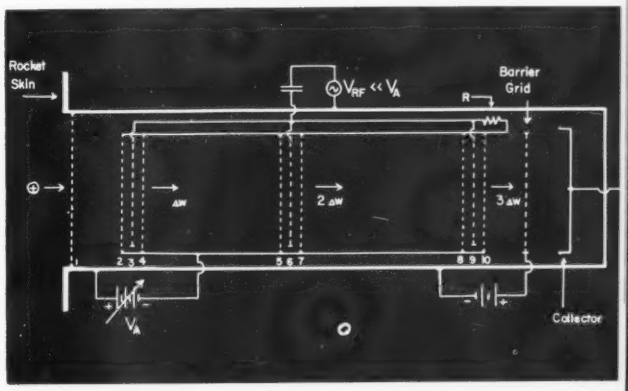
The heart of this experiment was a Bennett RF Mass Spectrometer specially adapted for the rocketborne application. This particular type of instrument was chosen, among other reasons, for its light weight of about 1 lb. No magnets are used, the mass separation being accomplished with electric fields. Three separate spectrometers were flown in each rocket, one each to analyze positive and negative ions and one for the neutral gas. The spectrometers were nearly alike in construction, the main difference being an ionization source placed at the inlet of the neutral-gas spectrometer.

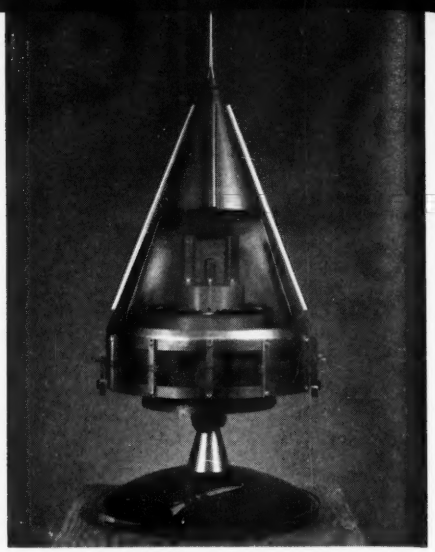
The mass analysis operations for each spectrometer are identical. A simplified schematic sketch of the positive ion tube is shown at right. The analyzer elements—planar wire-mesh grids mounted perpendicular to the tube (CONTINUED ON PAGE 102)



The nose of this Aerobee-Hi, shown being prepared for an IGY launching at Fort Churchill, carried three mass spectrometers for sampling the ionosphere.

Rocket-Carried Mass Spectrometer





Pioneer's radiation-detection instrument

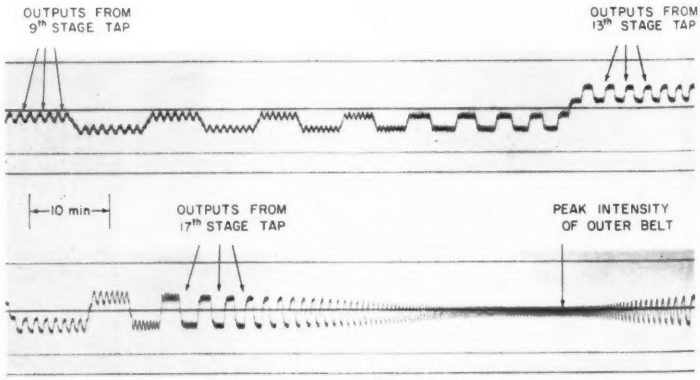
The beautiful engineering of the lunar probe radiation experiment, described here, represents a high point of electronics art and an intimation of things to come in space technology

By Conrad Josias

JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF.

Conrad Josias, a research engineer at CalTech's Jet Propulsion Laboratory, holds a B.E.E. from New York Univ. and an M.E.E. from Polytechnic Institute of Brooklyn. At Airborne Instruments Laboratory in Mineola, N.Y., from 1951 to 1956, he was active in the design and development of electronic devices and systems. Since joining JPL in 1956, he has participated in the development of transistor circuits for missile guidance systems and payload instrumentation. His present activities include teaching extension classes in transistor fundamentals at the Pasadena City College.

AT 12:10:56 a.m. EST, on March 3, 1959, a Juno II rocket system, launched from Cape Canaveral, Fla., injected an American payload into an escape trajectory that would pass within 38,000 miles of the moon and subsequently orbit the sun. The launching vehicle was prepared by the Jet Propulsion Laboratory and ABMA under NASA direction. Principal roles assigned to JPL in this venture were design and construction of the solid-propellant high-speed stages, design and construction of the lunar payload, trajectory planning, and deep-space telemetry and tracking. Payload weights in this first group of experiments in the Juno II program (referred to as Juno IIA) were limited to a modest 13–14 lb.



Telemetering record of Pioneer III radiation data monitored from Mayaguez, Puerto Rico, as the probe returned earthward.

One of the experiments assigned to the Juno IIA mission (Pioneers III and IV) was a measurement of radiation intensity along a nominal trajectory between the earth and the moon, and possibly beyond. Cognizance for this experiment was held by James A. Van Allen of the State University of Iowa (SUI), who had been so successful in recognizing the earth-girdling belt of high-intensity radiation detected by the radiation package contained in the early IGY Explorers.

JPL Designed Package

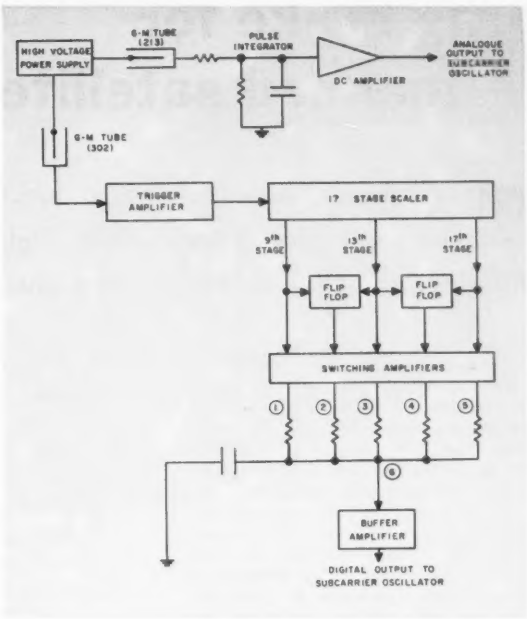
Dr. Van Allen's responsibility entailed definition of the experiment, calibration of the flight packages, and interpretation of flight results. Moreover, he specified the radiation detector for the experiment and outlined, in general terms, the type of system to be used with the detectors. The design and construction of the electronic "radiation" package containing counters, pulse circuitry, a high-voltage supply, DC amplifiers, and data coding and compression devices were done at JPL. The radiation package, which we will describe here, represents a high point of electronics art, and an intimation of things to come in space technology.

The payload associated with the first Juno IIA firing was Pioneer III, a display model of which is shown on the opposite page. This cone-shaped assembly did not achieve escape velocity, but soared to an altitude of 63,000 miles before returning to the earth. Although the lunar objective of this probe was not accomplished, measurement of the earthbound radiation fields was more complete than if the probe had escaped the earth's gravitational pull. Extensive data were compiled not only on the outward leg of the payload trajectory, but also on the return phase. The results of this experiment indicated, for the first time, the depth and contour of the partially explored radiation belt.

Two Geiger-Mueller tubes were used aboard Pioneer III as radiation detectors. One of the tubes was used as a standard particle detector, the other as an indicator of average pulse current produced by particle-induced ionizations. The basic uncertainties that existed in the experiment pertained to the precise nature and energy of the radiation being measured. These problems notwithstanding, the quantitative space profile was considered to be of considerable interest and value on an exploratory mission. A package of identical design was flown aboard Pioneer IV with 4 grams/cm^2 of lead shielding around the current-integrating Geiger tube for the purpose of providing additional radiation intensity data.

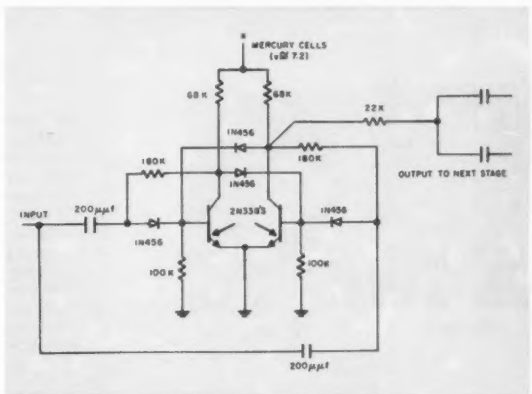
As originally conceived (CONTINUED ON PAGE 114)

Block Diagram of Radiation Experiment



Main Subassembly for Probe

Basic Scaler Flip-Flop



Drag brake for manned satellite recovery

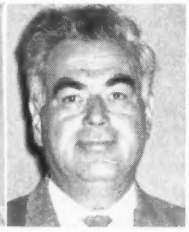
Simple in design, sophisticated in function, a unique umbrella-like steel drag brake offers high reliability, simple control, and less weight than comparable retrorocket systems

By R. W. Detra, A. R. Kantrowitz, F. R. Riddell, and P. H. Rose
AVCO-EVERETT RESEARCH LABORATORY, EVERETT, MASS.

The Avco-Everett Research Laboratory at Everett, Mass., conducts theoretical and experimental research in high-temperature gas dynamics and hypersonic flight. The Laboratory was created in 1955, under the direction of Arthur Kantrowitz, internationally recognized authority in these fields, to gain a fundamental understanding of the re-entry phenomena. The Laboratory has had the major responsibility for research on re-entry heating problems of intercontinental ballistic missiles, including the Atlas, Titan, and Minuteman.

This fundamental knowledge gained under the ICBM program is equally applicable to satellite re-entry, and formed the basic groundwork for solutions to manned satellite vehicle design. Over the past several years, continuous studies of the virtues of different satellite recovery techniques have led to the development of the drag brake concept. In the development of the engineering details of the concept, the Avco-Everett Research Laboratory has been aided by several of the other divisions of Avco Corporation, in particular, Lycoming.

Detra



Kantrowitz

Riddell

Rose

THE MANNED satellite designs which have been discussed publicly are adaptations of aircraft or nose-cone technology. Instead of extrapolating one of these devices, we set out some time ago to make a "fresh approach" to the design of a manned satellite system. That approach led to a single basic device to achieve re-entry and landing—the drag brake pictured on the opposite page.

How did we arrive at this single basic device?

New Approach to Vehicle Design

The heating and the deceleration which must be faced by a human passenger during re-entry have dominated most manned satellite discussions. However, we feel that progress made during the ICBM program has allowed us to design a vehicle without over-emphasizing re-entry heating considerations. Also, progress in aeromedical research makes it clear that the 8-g decelerations which must be faced in a tangential constant-drag re-entry are not a serious problem. Consequently, it appears to us that the re-entry problem should not dominate the design of the vehicle.

It seems clear that the earliest manned satellite should be de-

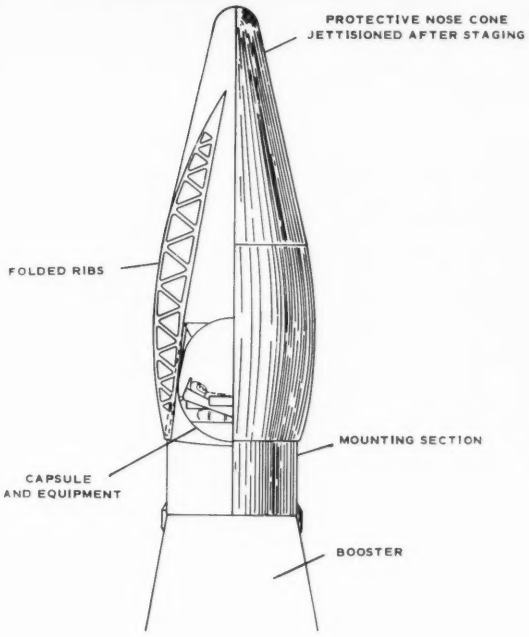
Weight Comparison of Drag Brake and Retrorocket Systems

Common Items		Retrorocket System*		Drag Brake	
Basic structure	167 lb	1. Added structure	133 lb	1. Zero	
Inhabitable capsule	133	2. Beryllium heat shield	398	2. Zero	
Escape system	695	3. Automatic orientation		3. Low torque	
Environmental equip.	70	systems	137	system	25.5
Pilot support	46	power	66		
Cockpit	17	4. Retrorocket	207	4. Zero	
Navigation aids	41	5. Recovery systems	165	5. Zero	
Communications equip.	212	6. Zero		6. Drag brake	425
Instruments	15	7. Zero		7. Second stage	
Recording equip.	24			escape	50
Power supply	157				
Programmer	9				
Man and suit	210				
Total	1796 lb		1106 lb		500 lb

Launch wt	2902 lb	2297 lb
Orbital wt	2207	1527
Re-entry wt	1914	1399

* From Avco RAD proposal Dec. 10, 1958

Drag Brake Satellite on Booster



Avco Drag Brake

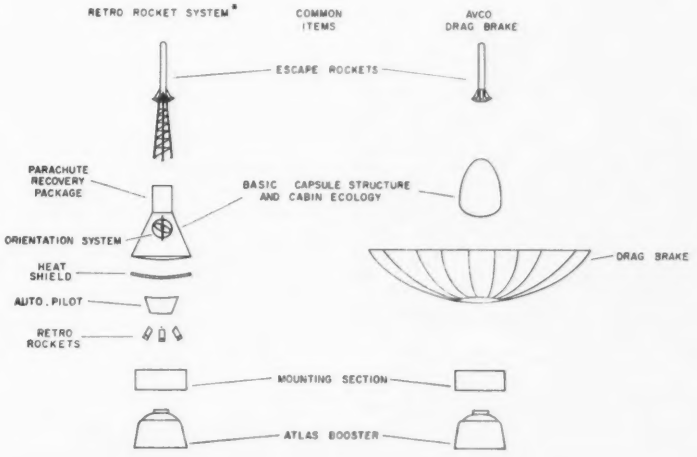
signed for flights ranging from one orbit to perhaps as long as several days. Its orbit must thus be high enough so that the deceleration due to aerodynamic drag is less than a critical value, which ranges between 10^{-4} and 10^{-6} g. The lowest altitude at which these flights can be achieved has the primary advantage that the aerodynamic forces are large enough to be useful in the recovery sequence.

The earliest manned satellite flights, then, will be made at altitudes with small but appreciable air density. In our design, this residual atmosphere is utilized to achieve satellite orientation and to provide the decelerating forces which effect re-entry and allow precise control of the landing point. In view of the fact that this altitude on the one hand is the minimum permitting true satellite flight, and on the other hand is the maximum allowing utilization of the residual atmosphere, it is a natural staging point in spaceflight. We have called this region the "orbit of decision."

There are a number of other problems which must be faced in the design of manned satellites. First, the high strength required of structures which protrude from the launch-vehicle envelope involves a great weight penalty. On the other hand, large surface areas are required to produce drag or other aerodynamic forces in orbit due to the tenuous upper atmosphere. These requirements dictate folding structures. A mechanism for effecting a satisfactory landing must also be (CONTINUED ON PAGE 90)

DRAG BRAKE VS. RETRO-ROCKET SYSTEM

The weight comparison at left and the component comparison right show the marked simplicity and weight advantage of the drag brake system. A retrorocket system for a manned satellite requires a device to orient the vehicle, a retrorocket with autopilot, a heat shield, and a sequence of decelerating parachutes. The drag brake performs all their functions.



* FROM AVCO RAD PROPOSAL, 10 DEC 1958

The NASA space sciences program

T. Keith Glennan

THE U.S. National Aeronautics and Space Administration is developing a national space sciences program on as broad a basis as possible. In the planning and programming, advantage is being taken of the advice of many specialists and experts in the scientific community. In the conduct of satellite and space probe experiments. broad participation of the scientific community and industry, along with government, is planned, and steps are being taken to secure such participation. The developing program has captured and increased the momentum in space research developed during the International Geophysical Year.

The present status of the national space sciences program is described in this report. For convenience, the subject of research in space has been divided into several broad areas: Atmospheres, Ionospheres, Energetic Particles, Electric and Magnetic Fields, Gravitational Fields, Astronomy, and Biosciences. For each area, the principal scientific objectives are stated, followed by a review of present knowledge and existing problems to be solved. Each section closes with a statement of the long-range program and the immediate program now underway.

The subdivision used is one of convenience only. Actually, the various areas are related in many complex ways. Investigations of the various interrelationships are a very important part of the search for a better understanding of many puzzling phenomena.

It is recognized that the national space sciences program is subject to continuing review, amplification, and modification as work progresses and scientific data and results are obtained from currently orbiting space vehicles. Moreover, desired scientific experiments must continuously be matched with the present and future capabilities and availabilities of vehicles, supporting technology, and facilities.

T. Keith Glennan
Administrator

ATMOSPHERES

OBJECTIVES

To determine and understand the origins, evolutions, natures, spatial distributions, and dynamical behaviors of the atmospheres of the earth, moon, sun, and planets; and their relations to the medium of interplanetary space. To investigate atmospheric phenomena associated with interactions between photons, energetic particles, fields, and matter. To understand the relations between the earth's upper atmosphere and its surface meteorology. To evaluate atmospheric effects on instrumented and manned spaceflight.

PRESENT KNOWLEDGE

The Earth's Atmosphere

The structure, i.e., temperature, pressure, and density, of the earth's upper atmosphere is partially known from indirect observations and from rocket soundings at New Mexico, Fort Churchill, Canada, in the Arctic, and on the equator. Up to about 110 km altitude, density and pressure both fall off by roughly a factor of 10 for every 10-mile increase in height. At higher altitudes, the rate of decline in density and pressure is markedly slower. Starting from the ground, temperature falls steadily with height until at about 12 km (in temperature latitudes), the temperature reaches a minimum of about −55 C at between 50 and 60 km. After that there is a sharp decline in temperature to probably less than −75 C at between 80 and 85 km height. Throughout the E and F regions of the ionosphere, kinetic temperature rises to 1000 C or more, and perhaps to above 2000 C. The structure parameters vary with both time and geographic position. Pressure, for example, varies by at least a factor of 2 at 100 km and by a factor of 6 or more at 200 km. Indications from rocket measurements are that variations by orders of magnitude in pressure and density may be expected at F-region altitudes and higher.

The composition of the atmosphere is essentially the same from sea level up to the E region at 100 km. Small amounts of ozone are created by solar ultraviolet radiation, the maximum concentration being found at between 25 and 30 km in the daytime. In the E region and above, molecular oxygen dissociates to atomic form. Rocket observations at Fort Churchill have shown a marked diffusive separation of argon relative to nitrogen starting at altitudes between 100 and 120 km and increasing into the lower F region.

Rocket wind measurements and indirect ground-based observations have indicated fast moving winds at all levels of the upper atmosphere. Typical speeds are 20 to 50 meters per second between 30 and 120 km, while speeds higher than 100 meters per second have been measured. In general, the winds are from the West and strong in winter, and from the East and weaker in summer. Marked wind shears have been observed in the E region of the ionosphere.

The Sun's Atmosphere

The sun's atmosphere may extend with decreasing density throughout the solar system. At a distance of about 20 solar radii (nearly 0.2 Astronomical Units), the atmosphere is still observable directly by its blurring effects on the radio stars seen through it. Near the earth's orbit, it is estimated that this atmosphere contains several hundred protons per cubic centimeter and has an electron temperature of 250,000 K.

The Moon's Atmosphere

The moon lacks any appreciable atmosphere, although a highly rarefied ionosphere has been indicated by radio astronomical observations.

Planetary Atmospheres

Mercury has no observable atmosphere and Pluto is too faint for an atmosphere to be detected through the terrestrial atmosphere. Atmospheres have been observed on each of the other planets and on one of Saturn's satellites.

Venus is covered by an extensive atmosphere in which CO_2 is the primary constituent. H_2O has not been identified there although it may be present below the opaque cloud cover which envelops the entire planet. The temperature of the top of the cloud layer has been measured with a thermopile as about 0 C. Radio astronomy measurements indicate a temperature of nearly 300 C lower in the atmosphere.

The Martian atmosphere is tenuous compared to the earth's, but H_2O and dust clouds have been observed there. The surface pressure has been estimated at approximately 8 per cent of the earth's sea level atmospheric pressure.

The atmospheres of the major plants (Jupiter, Saturn, Uranus, and Neptune) contain large amounts of H_2 and, presumably, He. Their spectra are dominated by bands of CH_4 and NH_3. The atmospheres of Jupiter and Saturn have a marked banded structure and exhibit differential rotation as does the solar photosphere. In addition, Jupiter shows such puzzling features as the famous red spot, white spots, and lightning-like radio emissions.

EXISTING PROBLEMS

The Earth's Atmosphere

Major problems connected with the earth's

atmosphere are exemplified by the following questions, the answers to which are only partially known or quite unknown.

1. What are the primary sources of energy affecting the high atmosphere, and at what altitude levels are these energies deposited in the atmosphere?
2. What is the average structure of the atmosphere above 80 km over the entire globe, and what are the variations in the structure parameter with respect to season, time of day, geographic location, and solar activity?
3. What is the detailed composition of the atmosphere above 100 km? At what altitude, if any, do the light gases H, H_2, and He predominate over O, N_2, and N?
4. What are the detailed dynamics of the high atmosphere, including the general circulation?
5. What is the relation of the Great Radiation Belt to the heating of the upper atmosphere, and what other sources and sinks of energy are there?
6. What is the energy budget of the low atmosphere and its relation to cloud cover and weather systems?
7. What are the relations between the earth's surface meteorology, its upper atmosphere, and solar activity?
8. What is the origin and history of the earth's atmosphere?

The Sun's Atmosphere

1. What is the composition of the solar atmosphere, particularly at planetary distances?
2. What are the density and temperature of the sun's atmosphere as a function of distance from the sun?
3. How does the sun's atmosphere interact with those of the earth and the other planets?

The Moon's Atmosphere

1. Does the moon have a trace atmosphere and, if so, what is its composition?
2. If the moon does have a trace atmosphere what are its origins, dynamics, and entrapment near the moon's surface?

Planetary Atmospheres

1. What are the major constituents of the planetary atmospheres?
2. What are the surface pressures and densitites?
3. What is the altitude variation of their atmospheric structures?
4. What are the atmospheric components that might support earth-type life?
5. Do their atmospheres contain oxidizers available for combustion?
6. Does Venus's atmosphere contain H_2O?
7. Of what does the cloud cover of Venus consist?
8. What causes the apparent changes in transparency of the Martian atmosphere, the so-called "blue clearing?"
9. What is the nature and cause of the famous red spot on Jupiter?
10. What is the nature and origin of the rings about Saturn?
11. What are the important dynamic features of these atmospheres?
12. Does Pluto have an atmosphere?

PROGRAM

Long-Range

Long-range plans for achieving the above objectives include: (1) Instrumented satellite stations around other planets; (2) rocket probes deep into the atmospheres of other planets including soft landings onto the surface with automatic and eventually manned recording stations; (3) probes deep into the solar atmosphere; (4) special probes for measuring the density and nature of gas and dust particles in interplanetary space and within comets; and (5) extensive theoretical studies to understand the basic natural phenomena taking place within the atmospheres.

Immediate

Short-range plans include extensive and intensive studies of the structure and composition of the earth's atmosphere from 80 km to several hundred kilometers by direct measurements with sounding rockets and with satellites. Diurnal, latitudinal, and temporal variations in these parameters will be determined and will be correlated with the energy and momentum balances in the earth's upper atmosphere. Models of the earth's atmosphere will be formulated for (1) providing basic data needed in understanding ionospheric, auroral, and other phenomena; (2) providing guidance in the study of the atmospheres of other planets; and (3) providing essential information in the engineering design of the man-in-space launching, guidance, and recovery systems.

Short-range plans for studies up to 80 km include a large number of synoptic rocket flights and several cloud cover satellites to establish the relationships between surface meteorology and the structure and dynamics of the upper atmosphere. These data are vitally needed to improve weather forecasts and to eventually permit control of certain aspects of the weather.

Immediate steps in the atmospheres research program are: (1) Initiation of extensive instrumentation and systems development contracts for measuring atmospheric structure and composition as gas densities of from 1 to 10^{-13} atmospheres; (2) adaptation of currently available atmospheric structure instruments for an unmanned earth satellite; (3) continuation and improvement of IGY rocket soundings to determine the vital factors in the large variations noted in the IGY atmospheric structure flights; (4) the development of an inexpensive synoptic meteorological rocket system to permit rapid collection and analysis of data up to 80 km; (5) rocket test flights for proposed satellite instrumentation systems; (6) launching of the remaining Vanguard meteorological satellite to study radiation balance in the earth's atmosphere; (7) completion of the test phases and flight phase of the ABMA radiation balance satellite; and (8) the launching of a 12-f inflatable sphere to obtain satellite drag data from which atmospheric densities can be computed.

IONOSPHERES

OBJECTIVES

To determine and understand the sources, natures, spatial distributions, and dynamical behaviors of the ionized regions of the solar system, including the ionospheres of the earth, moon, and planets. To investigate ionospheric phenomena resulting from interactions between photons, particles, ions, and magnetic, electrostatic, and electromagnetic fields. To understand relations between solar activity and the terrestrial and other planetary ionospheres, magnetic fields, and upper atmospheric current systems. To evaluate ionospheric efforts on instrumented and manned spaceflight, including communications.

PRESENT KNOWLEDGE

The terrestrial ionosphere which extends from an altitude of 60 km into interplanetary space is formed by the ionization of neutral particles, primarily by radiation emitted from the sun. The density of ionization is not uniform. The altitude regions of maximum ion density during daytime are designated D, E, F_1, and F_2. Additional sporadic ionization can occur at various levels, particularly in the E region. Normal D-region ionization extends roughly from 60 to 85 km, with maximum values no greater than a few thousand electrons per cubic centimeter. Average altitudes at which maximum densitites in the E, F_1, and F_2 regions occur are 105, 150, and 300 km, corresponding to concentration of 1.5, 2.5, and 20 x 10^5 el/cm^3. These values are for a summer day at New Mexico during the period of maximum solar activity. Gradients in the lower E and F_1 regions are roughly 104 el/cm^3 per km. Very recent results indicate that the concentration above the F_2 region experiences a very gradual decrease to a value of 103 el/cm^3 at a height of 10,000 km.

At night, the density of ionization in the D, E, and F_1 regions decreases by at least an order of magnitude. The concentration decreases by less than this factor in the F_2 region, with the result that the night-time ionosphere shows a single F region predominant, with comparatively little ionization below 170 km.

The E-region altitude is relatively insensitive to latitude. However, the F-region height is greatest over the equator and decreases by 100 km at temperate latitudes. Ionospheric irregularities are strongly dependent on geomagnetic latitude, with extremely irregular conditions occurring in the auroral zones. The electron density varies strongly with the solar sun spot cycle, by as much as one order of magnitude in the F_2 region. The major ionized constituents of the E and F regions are nitric oxide and atomic oxygen, respectively.

The ionosphere makes possible communication over large distances by reflection of frequencies below the critical frequency. Typical values of these critical frequencies are 3 to 4 mc for the E region and 5 to 15 mc for the F region. It should be emphasized that since ionospheric structure is dependent upon diurnal, seasonal, latitude, and solar effects, so are its propagation characteristics. In the lower ionosphere, such phenomena as photoemission, diffusion, and the rectifying action by antennas result in charging space vehicles with potentials up to 20 volts.

Very little is known about the ionospheres of other planets. There are indications of thunderstorms on Jupiter and possibly Saturn, and of auroras on Venus.

EXISTING PROBLEMS

Although ionospheric structure is being studied by vertical incidence radio sounding from surface stations, this method gives results only up to the F-region maximum and provides only integrated effects. Past experience has shown that rocket and satellite measurements of electron density versus actual height are needed to interpret the surface ionosphere sounding records correctly, and thereby permit their use on a practical synoptic basis.

Since rocket measurements have not been made in sufficient number above the F_2 region and since they have intercepted only an extremely small portion of the ionosphere for small time intervals, the most important unknowns are the details of ionospheric structure, particularly above the F_2 region, as a function of time, season, latitude, and solar and cosmic activity. Collision frequencies and the ionic composition (particularly at low mass numbers) require special investigation.

Present knowledge of ionospheric propagation characteristics requires extension. Needed are explanations for anomalous fading effects; polar diagrams of upcoming and downcoming waves and waves along the magnetoionic ducts; experimental verification of the theories of whistler and Z-mode propagation; the frequencies at which heavy ions influence propagation (hydromagnetic waves); and investigation of the probable existence of very low frequency windows useful for interplanetary communications. Definition of ionospheric structure and propaga-

tion characteristics is important to such problems as the calculation of tracking errors in AICBM radars and the choice of communications frequencies.

The interaction between charged particles in the ionosphere with space vehicles is one of the least understood phenomena of spaceflight. Measurements of vehicle charge, particularly in the Great Radiation Belt and in regions where photoemission effects can become serious (exosphere), are needed to compute possible electrical drag and missile trajectory errors.

Propagation characteristics of the exosphere, and the intensity and nature of cosmic noise, need investigation, particularly in the frequency range which is most affected by the ionosphere. These data are important to radio astronomy observations from space vehicles.

Since so little is known about other planetary ionospheres, discovery and survey type investigations of them are needed first. Then their structure and propagation characteristics also will need to be studied.

PROGRAM

Long-Range

The long-range program will exploit current techniques for determining the terrestrial ionospheric structure, its propagation characteristics, and its influence on spaceflight, by observation from below, within, and above. New techniques for evaluating the least known parameters will be developed. All of the applicable methods will then be used for the study of other planetary ionospheres. Eventually, propagation sounding stations may be established on the surface of the moon. All the data will then be applied to understand the interrelations between solar activity, magnetic fields, the aurora, the Great Radiation Belt, and other phenomena.

Immediate

The immediate program is concerned with obtaining electron density profiles at altitudes above the F_2 layer by propagation experiments in sounding rockets. Then, latitude and temporal variations of this parameter will be obtained by use of a satellite beacon. Topside sounders in satellites will be used for synoptic studies of electron density in the outer ionosphere. This technique promises lesser ambiguity than that obtainable from satellite beacons. Present knowledge of electromagnetic propagation will be extended by the inclusion of very low frequency receivers in polar-orbiting satellites and space probes. Ion spectrum studies will be extended to lower mass numbers and higher altitudes by the inclusion of r.f. mass spectrometers in space probes and satellites. Direct measurements using devices such as antenna probes, ion probes, and electric field meters will be made in rockets and satellites, to better define ionospheric structure and to study the interaction between the ionosphere and space vehicles.

ENERGETIC PARTICLES

OBJECTIVES

To determine and understand the origins, natures, motions, spatial distributions, and temporal variations of particles having energies appreciably greater than thermal. To understand interactions between such particles, fields, photons, and matter. To evaluate possible hazards to life and other effects of energetic particles and photons on instrumented and manned space exploration.

PRESENT KNOWLEDGE

Cosmic rays are an important constituent of the energetic charged particles which are known to be present in space. It is now certain that cosmic rays consist primarily of high energy hydrogen nuclei, plus a small percentage of energetic nuclei of heavier atoms. The heavier cosmic rays are largely energetic helium nuclei but include masses up to that of iron. It has been determined that the cosmic ray energies cover at least the range from a few billion to a billion billion electron volts. Over this energy range the spectrum is such that the cosmic ray intensity falls rapidly with increasing energy. Because of this spread of individual particle energies, and because of the magnetic field of the earth, fewer cosmic rays strike the earth's upper atmosphere at the equator than at higher latitudes.

On striking the atmosphere, the cosmic rays produce many secondary particles including electrons, many types of mesons, and fragments of atomic nuclei. Most of these secondaries are absorbed by the atmosphere, but a few reach the earth and some scatter back out of the atmosphere. The intensity of these secondary particles just above the atmosphere is comparable with the cosmic ray intensity but decreases as the distance above the atmosphere increases. The cosmic ray intensity is not a constant but varies with the sunspot cycle and with magnetic storms and solar flares.

Another group of energetic particles in space comprises the particles which produce auroras. These particle streams contain electrons having energies over at least the range from a few hundred to a few thousand electron volts. Also present are hydrogen nuclei having energies over about the same range as the electrons. On striking the atmosphere, these particles ionize and excite the air atoms, producing the light we see as auroras.

A third class of energetic particles known to exist in space comprises the Great Radiation Belt. These particles are in a belt surrounding the earth at latitudes less than 70 deg and at altitudes between about 600 and 30,000 miles. The intensity of the radiation in the belt is thousands of times that of the cosmic rays. It seems clear that the radiation belt is the immediate source of the auroral particles.

EXISTING PROBLEMS

Among cosmic ray problems, important phenomena to investigate are: The sources of the primary cosmic rays; the processes by which the particles obtain their high energies; their distribution in space; their variations in intensity and composition with time; their energy spectrum, particularly at lower energies; their interrelations with the auroral and radiation belt particles; their effects on both animate and inanimate objects; and their detailed composition, including the possible presence of anti-matter.

In the field of auroral particles, the following are unknown: The origin and acceleration mechanisms of these particles; their presence or absence in space and near other planets; their rapid variations in intensity and spatial distribution; their detailed composition; and their relations with cosmic rays, radiation belt particles, magnetic fields, the sun, the ionosphere, and with upper-atmosphere processes.

Among the unknowns associated with the Great Radiation Belt particles are: The composition and energy of the particles; their origins; the lifetime of the particles; their spatial extent; their possible variations in composition and intensity; their effects on animate and inanimate objects; and their relations to cosmic rays, auroral particles, magnetic fields, the sun, and upper-atmosphere processes.

PROGRAM

Long-Range

In situ measurements using deep-space probes will be made from the close proximity of the sun to the limits of the solar system. Extensive measurements in the vicinity of the planets, especially the earth, will be made to determine the interaction of the energetic particles with the atmospheres and fields of these bodies. These measurements will require satellite orbits around the earth, the moon, and other planets. The establishment of an observatory on the surface of the moon or on some other planet might be necessary, depending on the data previously acquired by artificial satellites.

Immediate

In the near future, the measurements of energetic particles will be pursued with satellites and rockets in the vicinity of the earth and with interplanetary probes. These measurements will be aimed at determining the interactions of these particles with the earth's atmosphere and field, their interactions with interplanetary fields; the types and energies of these particles; their spatial distribution; and the origin of the energetic particles.

The immediate program includes specifically measurements of the cosmic ray intensity in interplanetary space; of time and latitude cosmic ray intensity variations; of the composition and spatial extent of the Great Radiation Belt; of the cosmic ray energy and charge spectrum; and of the nature of the particles producing auroras.

ELECTRIC AND MAGNETIC FIELDS

OBJECTIVES

To determine and understand the origins, natures, methods of propagation, spatial distributions, and temporal variations of magnetic and electric fields throughout the universe. To understand interactions between these fields and matter in space, and the influence of existing fields on solar and planetary atmospheres. To use these fields in the investigation of the internal constitution of astronomical bodies. To evaluate their effects and interactions on instrumented and manned space exploration.

PRESENT KNOWLEDGE

The earth's main magnetic field is approximately that of a dipole located at the earth's center but tilted at an angle of 11 deg with respect to the earth's axis. The strength, orientation, and uniformity of the main field varies slowly with time. This is called *secular variation*. The field at the earth's surface is also geographically irregular due to differences in the geology of the earth's crust. These irregularities are called *anomalies*. On a time scale of months, rather than years, the above features appear constant at a given location. However, using a time scale of days, hours, or minutes, a sensitive instrument shows that the field is practically never constant at any location on the earth's surface. These variations are usually classified as: *diurnal*—the variations that occur in 24 hour cycles and appear similar from day to day; *magnetic disturbance*—large variations that are not a daily event in which the field changes are often highly irregular for periods of several or more hours over either small or large areas of the earth's surface; *magnetic storms*—large variations which occur more or less simultaneously over the entire surface of the earth; *sudden commencements or impulses*—abrupt changes in the magnetic field which sometimes precede magnetic storms; *pulsations*—sinusoidal oscillations of the magnetic field with wave periods of fractions of a second to five minutes which frequently persist for one or more hours and sometimes as long as half a day.

The magnitude and frequency of occurrence of these variations is a function of geomagnetic latitude. The largest diurnal variation is observed at the magnetic equator. The largest disturbance and storm variations occur in the auroral zones in association with visible auroras. Sudden commencements and impulses tend to be worldwide. Pulsa-

tions are most prominent in high latitudes and reach their greatest magnitude in the auroral zones.

From the study of surface measurements and from theory, it is believed that these variations are caused primarily by electric currents in and above the ionosphere. The currents are attributed to the dynamo action of tides and winds in the ionized gas and to the influx of particles from the sun. Recent thinking on hydromagnetic phenomena has led some theorists to believe that interactions between the outer portions of the earth's field and the motion of solar gas clouds also contribute to the variations. It has not, however, been possible to prove any theory or establish an understanding of the phenomena solely from surface measurements. Here lies the importance of direct measurements from space vehicles.

Sensitive magnetometers have been successfully flown into and through the E region. These flights demonstrated the existence of electric currents in the lower ionosphere at the magnetic equator and in the auroral zones, and showed the expected decrease in field intensity with altitude. More than anything else, they showed the need for more measurements.

The magnetic fields of the sun and other stars have been studied intensively, but it cannot be said that there is concrete knowledge of their strength and form. Indirect measurements and theories permit a wide range of possibilities. Galactic field intensities have been estimated from theoretical considerations and the study of light polarization. Values between 10^{-3} and 10^{-6} gauss have resulted. Theoretical studies of planetary fields, other than the earth's, apparently do not exist, and methods of indirect measurement have not been found.

An electric field exists between the earth and its ionosphere, corresponding to an average potential difference of 290,000 volts. There is no direct knowledge of the existence of magnitude of electric fields outside the ionosphere. Theories of the origins and accelerations of auroral particles and cosmic rays allow a wide range of possibilities for interplanetary electric field values.

EXISTING PROBLEMS

The unknowns of most urgent interest are usually those which are most apparent. The most apparent unknowns in magnetic field phenomena are the sources of field variations and the relationships between these variations and other solar-terrestrial phenomena. It is known that some variation is due to ionospheric currents, but the existence, location, and strength of possible electric currents above the ionosphere is not known, even though their existence appears probable. Strictly speaking, the cause of ionospheric currents is not known and even less is known about probable causes for currents above the ionosphere.

The form of the earth's main field is at least approximately known close to the earth, but at distances of 5 to 15 earth radii, where the field is most effective in guiding solar particles, radical departures from prediction can be expected. The field may expand and contract in response to motions of solar and interplanetary gas clouds. These distortions may in turn propagate as hydromagnetic waves down to the ionosphere and even to the earth's surface. The possibilities can only be considered speculative until field measurements are made in the outer reaches of the earth's field.

At some distance, the earth's field will blend with interplanetary and/or interstellar fields. Estimates of interplanetary fields range from 10^{-3} to 10^{-6} gauss. The strength and orientation of these fields is especially important to the understanding of how solar particles reach the earth.

Theories concerning magnetic fields on other planets are practically nonexistent. One reason for this scientific void is probably the lack of understanding of why the earth has a magnetic field. It is generally thought that the earth's main field is due to dynamo currents in the liquid core, but the form and cause of these currents is still an open question which may be related to the initial formation of the earth. This lack of understanding is, however, one of the principal reasons for obtaining measurements of the fields of other planets which formed under different conditions and have a different composition. Similar thoughts suggest that knowledge of the moon's magnetic field would be a major step toward determining how it formed as an earth satellite.

Direct measurements of the electric fields exterior to the earth's ionosphere and in interplanetary space are important to the eventual understanding of how cosmic rays and auroral particles are accelerated and from whence they come.

PROGRAM

Long-Range

Results from satellites, probes, and rockets to be flown in 1959 will be an important factor in determining the long-range program for studying the earth's fields. One can, however, anticipate that an important item will be establishing an earth satellite observatory which will include instruments for measuring particle flux and solar radiations as well as magnetic and electric field instruments such that direct correlations can be made between the various phenomena. Also, rocket soundings into the ionosphere will continue to be used to study details of ionospheric currents more thoroughly.

The fields of the moon, Mars, and Venus will first be measured from probes making close approaches, and eventually from packages landing and serving as observatories.

Probes will be shot at the sun to obtain solar field measurements as close to the sun as feasible.

In all measurements except the rocket soundings, the experimental intent will be to obtain both the absolute magnitude and the direction of the magnetic field measured. It will be more difficult to separate the ambient electric field from that due to an electric charge on the spacecraft.

Theoretical analyses and correlations between electric and magnetic field phenomena and other phenomena will be an integral part of the program.

Immediate

The short-range magnetic field program includes: (1) A number of small sounding rockets with proton magnetometers for studying ionospheric currents; (2) Two sounding rockets primarily for flight testing of newly developed Rubidium vapor magnetometers and information on radiation belt currents; and (3) A space probe to the moon with a Rb-vapor magnetometer for measuring electric currents and the form of the earth's field at great distances, interplanetary fields, and the moon's magnetic field.

The program also includes instrument development—the most significant being the development of Rubidium vapor magnetometers by Varian Associates. It is also anticipated that simpler magnetometers which can detect only the existence of a perceptible field will be placed in several rockets and space vehicles as secondary experiments.

GRAVITATIONAL FIELDS

OBJECTIVES

To determine and understand the origins, natures, methods of propagation, spatial distributions, temporal variations, and effects of gravitational fields throughout the universe. To determine and understand the external form and internal constitution of the earth, planets, and stars. To determine and understand the relations between gravitational and electromagnetic fields. To evaluate effects of gravitational fields or different magnitudes, including weightlessness, on instrumented and manned space exploration.

PRESENT KNOWLEDGE

At the present time, the best theory of the nature of gravitation is Einstein's general theory of relativity, which asserts that the force which we recognize as gravity results from a distortion of space-time. An essential part of this theory is the idea that mass as determined by gravitation will be found to be proportionate to mass as determined by inertia. Other theories have been proposed, especially by George D. Birkhoff.

There are three tests of the general theory of relativity. The first of these is the motion of the perihelion of Mercury, which amounts to 43 seconds of arc per year, agreeing quantitatively with Einstein's prediction. The second is the bending of light in the sun's gravitational field. It has been measured numerous times, and the results have generally been found to agree with Einstein's predictions, but in view of the smallness of the effect (only 1.75 seconds of arc), there is still room for reasonable doubt about the confirmation.

The third effect is the shift of light toward red wavelengths in a strong gravitational field. This is doubtfully observed in the sun, where it is confused by mass motions of gases. A red-shift is observed in some white-dwarf stars, but even there it cannot be unequivocally said that this is not an effect of mass motion.

It is further believed that the force of gravity is proportional to the density of matter in the universe. Since the universe is expanding, this means that changes of the order of one part in 10 billion per year ought to exist in the force of gravitation.

With respect to the gravitational field of the earth, this problem would be fully solved if we knew all the harmonics into which the field can be subdivided. There is one zero harmonic which amounts to the product of the gravitational constant by the mass of the earth, and which has at the present time, the value of 3.9868 with an uncertainty amounting to one part in 100,000. There are three possible first harmonics which arise from the displacement of the center of the earth from the center of our present coordinate system. This displacement is believed to amount, at the present time, to no more than 100 meters. There are five second degree harmonics, of which one harmonic of zero order is intimately related to the flattening of the earth and has been measured with great precision from the motion of the node of 1958 Beta 2 (Vanguard I). Coefficients so obtained correspond to a flattening of 1/298.3. Two of the remaining four are necessarily zero, and the remaining two have been doubtfully evaluated with an amplitude of about 4 mgals.

Of the seven third-degree harmonics, the zonal harmonic of zero order very recently has been measured, and appears to have a value of 5.6 mgals at the surface of the earth. The other six have been estimated crudely from gravity data. An estimate of 5 mgals has been made for the fourth zonal harmonic. It is known that the size of these harmonics is proportional to the stresses at the interior of the earth roughly at the rate of 1 mgal to 10 kg per square centimeter.

In the case of Mars, the zero harmonic (the mass) is 0.1076 that of the earth. Nothing is known with respect to first harmonics. The second harmonic is determined from the flattening which is found to be 1/192 from the satellite motions, and 1/77 from visual observation. Masses and flattenings for Jupiter, Saturn, Uranus, and Neptune are available

in the same way, but no higher harmonics are known for any of these planets.

The sun's mass is accurately determined by the motions of the planets. Nothing is known about any other higher harmonics.

Measurements of various double stars yield masses which are found to fall into the range from a tenth of the sun's mass to 50 times the solar mass. The flattening, which ranges from zero up to the limit of instability, is known for a few eclipsing binary stars.

The gravitational field of the galaxy as a whole has been deduced from the rate of galactic rotation. It is found to be equivalent to several hundred billion solar masses. The gradient of the galactic field which measures the flattening of the galaxy has also been determined from the gradient of galactic rotation near the sun.

The nature of the intergalactic gravitional field is at present completely unknown. It is not even certain that a repulsion does not exist at sufficiently great distances.

EXISTING PROBLEMS

With respect to the fundamental nature of gravitation, the principal problem is to find some peculiarity of the law which would serve to control the formulation of satisfactory theories. Such a pecularity might consist, for example, in a small deviation from strict equality of gravitational and inertial mass, or in a velocity of propagation, or in something in the nature of a shielding such as is observed with magnetism. Any one of these effects would give us a clue to the best direction to look for a more fundamental understanding.

Within the framework of the Newtonian Law, the classic problem is that of the long-time stability of a system such as the solar system. The problem may be formulated in this way: As we think of time of the order of 10^9 years, do the orbital planes of the planets tend to approach one another? Do the eccentricities tend to decrease? If so, then of course, we understand the architecture of our present solar system; if not, then we have an important clue which can some day be used to discover how it was initially formed. The problem of the stability of the solar system has engaged some of the best mathematicians since the days of Lagrange and Laplace, who found that stability could be guaranteed for times of the order of 10^8 years.

With respect to the gravitational fields of the planets, one problem is that of the presence of iron cores in the planets. At the present time, the large density (approximately 5) found for Mercury indicates a large iron core. It is hard to put this in an orderly relation with the density of Mars (about 3.9) and the moon (about 3.3). In particular, if correct, this density means that the iron core found in some planets cannot represent a pressure modification of ordinary silicate rock. A second test of the pressure modification idea is furnished by the density of Venus, which is just at the critical level. In both cases, it appears possible that further observational data would reverse the conclusions which have been drawn.

The gravitational field of the earth is closely related to a series of interesting problems. In the first place, the zero harmonic is essential for the study of space trajectories. Next, the internal constitution of the earth manifests itself through variations in the higher harmonics. In particular, a state of hydrostatic equilibrium in the interior of the earth demands the value of 1/297.3 for the flattening of the earth. The discrepancy between this and the observed value of 1/298.3 is a major problem in the structure of the earth. If the discrepancy is due to mechanical strength in the interior, then it may be related to the observed large values of some of the higher harmonics.

At the present time, two independent and contradictory theories have been offered for the inner structure of the earth and for the formation of mountain ranges. The first of these, which we might call the plastic theory, envisions a viscous interior in which slow convection currents of a few centimeters per year exist, and mountain ranges, such as those around the Pacific, are formed as the result of drag on the underside of the continents. The other theory, which we may call a crystalline theory, considers that the earth is slowly contracting as it cools, and attributes the formation of mountains to crumpling. At the surface of the earth, the problem of verifying or disproving the "basic hypothesis of geodesy," namely that the product of gravity anomalies in milligals times areas in square kilometers, does not exceed 30 for any extensive patches, is one of most important that can be set up.

PROGRAM

Long-Range

For the study of the fundamental nature of the gravitational field, two avenues are opened by our ability to launch satellites and space probes. The first of these is the ability to try experiments on a scale of hundreds and thousands of kilometers by probing the fields of planetary masses with bodies capable of being accurately observed. This is significant, because gravitational fields, except that of the earth, are almost unmeasurable in laboratory-scale experiments. In the second place, the periods of artificial satellites are so much shorter than those of the moon and other natural satellites that we can observe in a few years a number of revolutions corresponding to thousands of years for natural satellites. By the first avenue, we hope to find the links which must exist between the theory of the electromagnetic field and the gravitational field. It is planned in particular to test the equality of gravitational and inertial masses by experiments in space on a colossal scale, which are a repetition of the experiment of Galileo in the Leaning Tower of Pisa. An attempt will be made to devise experiments which will reveal the velocity of propagation of graviation, if any.

It is planned to determine the masses of the inner planets by direct observation of probes passing near them or possibly around them. These probes will at the same time help to determine the value of the astronomical unit, the fundamental meter stick of the solar system.

It is planned to test the hypothesis that gravitational attraction depends on the average density of matter in the universe, and that it therefore is slowly weakening as the universe expands. For this purpose, an atomic clock on the ground can be compared with a gravitational clock of some kind. A proposal for a gravitational clock, consisting, in effect, of a high satellite with a very well measured orbit, is being studied.

It is planned to employ moon probes to obtain improved values for the over-all mass of the moon and for the moments of inertia about its three principal axes. A determination of the strength of the materials in the moon's interior will be attempted from this information.

It is planned to measure the mass of Venus and of Mercury in order to test Bullen's idea about the nature of the cores of the planets.

Using the second avenue, it is planned to observe the motions of close satellites of the earth over a long period and to make a precise comparison with theory, searching for systematic trends in the inclination and the eccentricity, which might shed light on the history of the solar system.

Immediate

Studies are now being made on existing satellites with the object of determining the low harmonics of the earth's field from tracking data.

Preparations are being made for equipment for a special geodetic satellite which will be refining the observations on the harmonics, and of determining intercontinental distances with high precision. It will clearly be possible to carry the study of the form of the geoid much further than has been possible to date.

The information developed in the above studies will be applied to the question of the basic hypothesis of geodesy. This hypothesis, as formulated by some theorists, is in essence that the low harmonics of the earth's gravitational field have amplitudes of a meter or so. The hypothesis is not universally accepted. Other theorists consider that the amplitudes are of the order of scores of meters. A decision between these two hypotheses is important because Heiskanen, in particular, proposes extensive work based on Stokes' theorem—work which is only warranted if the basic hypothesis is satisfied. This information will also be used in an attempt to evaluate hypotheses of convection in the mantel. These hypotheses seem to go with the ideas of the first-mentioned school of theorists, and it may be possible to decide between these hypotheses and the alternative contraction hypotheses on the basis of our information.

It is also planned to put in orbit a satellite carrying a very precise clock in order to test a theory of Einstein which predicts a change in the clock's speed with a change in the strength of the earth's gravitational potential. If successful, this would constitute a new test of the general theory of relativity, and so improve our understanding of the nature of the earth's gravitational field.

ASTRONOMY

OBJECTIVES

To determine the spatial distributions of matter and energy over the entire universe, and to understand their cosmological origins, evolutions, and destinies. To observe from above the earth's atmosphere the spectral distributions of energy radiated from objects in the solar system, in this and other galaxies, and in the intervening space, with emphasis on observations that are prevented or compromised by the absorption, background emission, and refraction of the earth's atmosphere. To determine and understand the structure and the surface features of the planets. To determine the effects of meteors, radiations, and other astronomical influences on instrumented and manned space exploration.

PRESENT KNOWLEDGE

The field of astronomy may be broadly divided into five categories: (1) The solar system; (2) the stars; (3) interstellar matter; (4) the characteristics of stellar aggregates, such as clusters and galaxies; and (5) the history and evolution of the universe and its various components.

The Solar System

The dark bodies orbiting around the sun may be classified as planets, satellites, minor planets or asteroids, and comets. The nine planets, including the earth, differ primarily in size and in temperature. The smallest ones, such as Mercury, have too little gravitation to retain any atmosphere, while the larger planets, such as Jupiter and Saturn, have extremely dense atmospheres. Those planets closest to the sun have of course, quite high temperatures, whereas the most distant planets are very cold. With respect to the amount of atmosphere and to temperature, Venus, Earth, and Mars are intermediate, and these three planets are considered to be the only ones that might naturally support any form of life. Earth may be the only planet on which conditions are so ideal as to favor the evolution of intelligent life. Asteroids and most of the satellites of planets are small bodies, ranging from dust particles to

boulders a few hundred miles across. The comets are loose agglomerations of rock and gas that spend most of their time in the far reaches of the solar system and approach the sun at infrequent intervals. The asteroids and comets are probably the debris left over from the formation of the planets some 5 billion years ago.

The Stars

It is now known that the stars are gaseous bodies composed of about 75 per cent hydrogen by weight, 25 per cent helium, and traces of the remaining elements. Most stars derive their energy from the conversion of hydrogen into helium deep in the stellar interior, where temperatures and pressures are extremely high. This energy is transferred to the outer layers of the star by radiation and convection. There, the emerging light is affected by the constituents of the stellar atmosphere, producing the observable stellar spectrum. This spectrum, together with independent information concerning the star's luminosity and mass, is the basic datum from which all knowledge of the star's structure must be deduced.

A significant stellar characteristic is the fairly well-defined correlation between surface temperature, as evidenced by a star's spectrum or color, and intrinsic luminosity. The form of this temperature-luminosity diagram has yielded much information concerning the nature of stellar atmospheres. From the study of spectra it is found that the chemical constituents are approximately constant star to star. However, other parameters vary widely. Surface temperatures range from 1500 K to more than 50,000 K. Stellar diameters vary from less than 0.01 to more than 500 times that of the sun; masses range from 0.1 to 50 solar masses; and intrinsic luminosities vary by a factor of a hundred million.

The outer layers of a star are far from being in equilibrium. This is obvious in the case of the sun, where sunspots and their accompanying magnetic fields, intense hot spots called flares, and eruptions from the surface, called prominences, indicate large scale thermal and magnetic instabilities. The cause of these instabilities and, more basically, the reason for their 22-year periodic variation, is not yet understood. Other stars show even more striking examples of instability—stars which pulsate with periods of days or even hours; others which exhibit large, highly variable magnetic fields; and, finally, the novae and super-novae, which are subject to catastrophic explosions.

Interstellar Matter

The material between the stars has a composition similar to the stellar composition, in the form of individual atoms and radicals and small dust particles, or grains. The space density of this material is a few atoms per cubic centimeter and, except near hot stars, it has a kinetic temperature of about 100 K. In spite of the low density, the total mass of interstellar matter in the Milky Way is approximately equal to the total stellar mass. This material has a profound effect on stellar observations because its scattering reduces the intensity of starlight passing through it, and because it superposes interstellar absorption lines on stellar spectra. In addition, the material has a marked tendency to occur in clouds near hot, luminous stars, which themselves are often found in clusters. In these cases, the interstellar clouds are illuminated and become visible as reflection nebulae. If the nearby stars are hot enough to excite the gas, an emission nebula results, emitting energy primarily in the lines of hydrogen and of some of the trace constituents. In these nebular complexes, the density may be as high as a thousand atoms per cubic centimeter, and the kinetic temperature is usually about 10,000 K.

Knowledge of the interstellar medium has increased rapidly since the development of radio astronomy. Radio-frequency emission has been detected from the neutral hydrogen in the interstellar gas, and has proved to be a valuable tool in probing distant parts of the Galaxy. Thermal radio-frequency radiation has been observed from emission nebulae, and radio-frequency synchrotron radiation has been measured from nebular remnants of super-novae explosions. The polarization of starlight has indicated the existence of magnetic fields in the interstellar medium which may play an important role in the production of cosmic rays.

Star Clusters and Galaxies

Stars tend to occur in multiple systems of two to six stars and in clusters of tens to many thousands. The study of such clusters has been valuable because the members presumably have common origins and histories and thus present homogeneous populations suitable for statistical analysis. On a large scale, stars are clustered into galaxies containing billions of members. In appearance, these galaxies range from the smaller systems, which are spherical, ellipsoidal, or irregular, and composed of fainter stars and little interstellar gas, up to the massive, highly flattened, spiral galaxies which show a great deal of complex structure. Our galaxy, the Milky Way, is an example of the latter type. It consists of a central spheroidal nucleus of stars, surrounded by a round stellar sheet, quite thin compared to its diameter. Within this sheet, the galactic plane, the brightest stars and most of the interstellar material are concentrated into spiral arms. The sun is within such an arm. However, in addition to these stars, there is a second group of stars having different temperature-luminosity and velocity characteristics which are spherically distributed about the galactic nucleus. These so-called Population II stars are quite similar to the stellar populations of the smaller elliptical galaxies. It appears that spiral structure, with its associated interstellar material and bright stars may be a superficial and rather recent phenomenon superposed on an older and more fundamental stellar population of which all galaxies are composed.

Stellar Evolution

With the possibility in mind that there are stars with different ages and histories, the differences between the temperature-luminosity digrams of different groups of stars, and especially of different star clusters, may be interpreted as being due to age and evolutionary differences, as well as to small variations in chemical composition. Presently available evidence points to the following picture of galactic and stellar evolution.

The original material of the universe coalesced into discrete globs, or proto-galaxies and, in turn, stars and star clusters condensed out of these globs. After the initial period of star formation, those galaxies which had no excess material, or which lost their excess material through intergalaxy collisions, evolved into the elliptical galaxies. In the remainder, the excess material collapsed into flat sheets in which star formation has continued at a slower pace up to the present time. Star formation can occur when a local inhomogeneity in a dense interstellar nebula becomes large enough and dense enough to contract due to self-gravitation. The interior pressure and temperature eventually becomes sufficiently high to support thermonuclear reactions and the gas becomes self-luminous, after which radiation pressure prevents the accumulation of appreciable interstellar material. The size and luminosity of the new star are determined by the amount of material accumulated before energy production begins. Multiple star formation from a single cloud is common. In some cases, the nebular material remaining around a new star condenses into planets. Single stars not surrounded by planetary systems are probably rare.

Stars consume themselves by an ever accelerating process of converting hydrogen into helium until the hydrogen is exhausted. At this point the internal support of the star due to radiation pressure is removed and the main body collapses, while a tenuous outer atmosphere expands to tremendous proportions to preserve dynamic balance. The main body contracts until the central temperature and pressure become high enough to support the conversion of helium into heavier elements with an accompanying release of energy. During this evolution, the star may pass through phases of dynamic instability where pulsation occurs. Eventually, the star has no more energy resources left to support its mass and an implosion occurs, producing a nova. The postnova stellar core may then settle down into an extremely dense subluminous white dwarf star until it goes out completely.

CURRENT PROBLEMS

The Sun

The sun is the only star on which we can study small regions of the surface and atmosphere. For this reason, and because solar radiation profoundly affects the physical conditions in the earth's atmosphere, the sun is an object of prime importance for detailed study. To gain a better physical picture of the conditions in the undisturbed sun, more accurate measurements are needed of the solar constant and of the energy distribution in the entire solar spectrum, not just in the region observable from the surface of the earth. Also, particularly because of its effect on terrestrial conditions, a long-term study of the disturbed sun in all wavelengths, especially in very short optical wavelengths and in very long radio wavelengths, is of great importance.

The causes and nature of the phenomena occurring in the solar atmosphere and their effects on physical conditions in interplanetary space are of vital importance in the climatology of the planets. Some basic problems involve the propagation of disturbances through the solar atmosphere, the role of convective transport of energy in this atmosphere, and the origin, support, and heating of the chromosphere and corona.

The Solar System

There are still many pertinent questions concerning the physical characteristics of the planets and the other constituents of interplanetary space. More information is required on the percentage concentration of oxygen, water vapor, and other important gases in planetary atmospheres, the physical properties of the planetary surfaces and the structure of planetary interiors. Since the maximum intensity of the thermal radiation from the planets occurs in the infrared, it is obvious that studies in these wavelengths are important for deriving the physical characteristics of the planetary surfaces. The important band spectra from planetary atmospheres tend to occur in the infrared also. In addition, even those absorptions in the region of the spectrum accessible from the earth's surface are partially obscured by similar molecules in the terrestrial atmosphere. Finally, the information needed on the structure of planetary interiors can best be derived by studying the effects of these planets on nearby satellites, and should eventually prove particularly useful for this purpose.

An interesting question is that of the existence of a permanent interplanetary gas. If this exists, is it primarily the interstellar gas through which our solar system is moving or is it matter ejected from the sun or part of the solar atmosphere? The existence of such a nebula would provide a laboratory for studying general nebular properties, and for study-

ing at first hand a gaseous nebula surrounding a star. In addition, the existence of a solar nebula may also limit our study of nebulae elsewhere in the stellar system.

Stellar Physics

More accurate information is needed on fundamental quantities such as stellar masses, radii, and luminosities. For stars much hotter or much cooler than the sun, the luminosities must be extrapolated from the very small spectral region accessible from the surface of the earth to the regions which contain the predominant energy output of these objects. In the field of stellar atmospheres, more information is needed on the relative importance of radiative transfer as compared to the transfer of energy by mass motion and on the origin and effects of stellar rotation and magnetic fields. Important information on these problems is provided by the relative energy output in widely separated regions of the stellar spectrum. Our current knowledge of stellar composition, structure, and evolutionary processes depends upon spectroscopic observations in a relatively limited region of the spectrum. It is obviously desirable to extend our observations over the entire electromagnetic spectrum. These observations are especially important for the hot stars which are in rapid evolution. Both their maximum energy output, and the spectral lines which are critical for studying the abundances of important elements in these stars, are in the currently inaccessible ultraviolet.

Interstellar Medium

In the study of the interstellar medium, the question of the energy balance has been reopened by recent rocket investigations which show more ultraviolet energy being released by radiative processes than had been previously supposed. Additional information is needed regarding the nature of interstellar grains, their lengths, particularly in the infrared, and their interaction with the interstellar magnetic fields. In studies of the interstellar gas, astronomers have been handicapped by the lack of observation in the ultraviolet portions of the spectra where the principal spectral lines of the interstellar gases lie. These data promise to supply vital information on the chemical composition, distribution relative to galactic features, and the mass motions and excitation processes which play an important role in the evolution of our galaxy.

Star Clusters and Galaxies

Star clusters, galaxies, and clusters of galaxies constitute the large-scale building blocks of the universe. The role and mechanism of these associations remain questions basic to the solution of the origin and evolution of our universe. The individual properties of the star cluster and the galaxy, such as mass distribution, mass-luminosity ratio, angular momentum, gas and dust concentration, and energy balance, are typical of the parameters needing study. At present, we have little knowledge of the nature and density of the material in intergalactic space, as observations in the visible spectrum have proved inconclusive. It is desirable to carry the observations into ultraviolet portions of the spectrum, where higher absorption can be expected to greatly increase the sensitivity of these measurements. Current theories in cosmology depend strongly upon the correct interpretation of the red shift. It is desirable to determine if this red shift is a constant over the whole electromagnetic spectrum, and also if it is a linear function of distance. Since the red shift for very distant galaxies is sufficient to shift the normally observed spectral features into the unobservable infrared, detailed studies of the ultraviolet region of nearby galaxies, and the infrared of very distant galaxies, are essential to the detection of possible evolutionary effects during the billion or more years it has taken the light from the latter to reach the earth.

PROGRAM

Long-Range

The great distances of astronomical objects outside of the solar system mean that they are both small in angular dimensions and apparently faint. Hence, for wavelengths shorter than 1 meter, the objects require long periods of observation with large radiation collectors having good angular resolution and accurate pointing. Radio astronomical observations in wavelengths beyond the ionospheric limit require extensive antennae arrays to achieve good resolution. Thus, until an observatory on the moon is possible, experiments in this wavelength region will be limited to the sun and to low-resolution reconnaissance surveys. In the short-wave radio regions, astronomical sources are weak. It is possible that the development of large inflatable balloons will provide the necessary collecting area for observations in this region. To provide the necessary pointing accuracy and observing time for experiments in the infrared, optical, ultraviolet, and x-ray regions of the spectrum, development has begun on an orbiting stabilized platform. It will be possible to point this platform toward any point in the sky and to hold it in that direction for periods from a few minutes to an hour with sufficient accuracy to allow continued observations of individual celestial objects. The satellite will contain instruments of moderate size which can be completely controlled from the ground, thus providing a remotely operated observatory. Although the sky above the earth's atmosphere will be dark, the presence of sunlight scattered within the vehicle itself may be disturbing. The eventual establishment of an astronomical observatory on the moon will eliminate this difficulty, since the moon itself can provide an effective shield against the sunlight. Moreover, the establishment of an observatory on the moon will undoubtedly make feasible larger equipment than can be placed on a satellite-borne platform.

The execution of these programs will require not only the development of a stabilized platform and its pointing controls, but also specialized optical equipment and radiation receivers for particular wavelength regions, especially adapted for a particular program, and improvements in telemetering techniques so that transmission to ground stations of spectroscopic data of adequate scope and resolution will be possible. For planetary studies, the planetary satellites and planetary probes planned for the atmospheres program will also be useful for providing information on the surface conditions and interior structures of the planets.

Immediate

The immediate program includes the exploration of the moon, reconnaissance measurements in the ultraviolet region of the spectrum to determine the brightness and positions of interesting regions of the sky, preliminary testing of equipment and techniques to be used later on the stable platform, and studies of the sun in the ultraviolet and x-ray region with pointing controls somewhat less stringent than those to be used for the stable platform. The reconnaissance will continue and extend to the southern sky the survey of the newly discovered extended emissions in the far ultraviolet in order to determine the nature and sources of these emissions. Stellar photometry measurements will be made in the near and far ultraviolet spectral regions to extend the magnitude systems to these wavelengths. Emphasis is being given to observations in the previously unexplored far ultraviolet and high energy gamma-ray spectral regions. Studies of the solar ultraviolet and x-ray spectra will include their long-term variations, line profiles, distribution across the disk, and the spectra of the coronal x-ray emissions. In addition, long wavelength radio receivers will be placed in satellites to study the brightness distribution of the sky in these wavelengths, the spectrum of the sun and its variation, and the absorption of the earth's ionosphere at various heights.

BIOSCIENCES

OBJECTIVES

To determine the effects on living terrestrial organisms of conditions in the earth's upper atmosphere, in space, and in other planetary atmospheres. To determine the effects of flight through space on living organisms. To investigate the existence of life throughout the solar system, and to study in detail whatever extraterrestrial life forms exist.

PROBLEMS

The opportunity now exists to conduct fundamental life sciences research in satellites and space probes. In such research, conditions in space and conditions during flight through space enter as new experimental variables. Principal interest lies in the components of the space and spaceflight environment that are irrevocably different from the terrestrial, such as radiation and the altered gravity state. The former is qualitatively and quantitatively different from terrestrial radiation and looms as a far more important problem than originally thought. The latter offers the possibility of elucidating biological processes known to be affected by weight or apposition of one part against another, such as cell division and organogenesis. These and other areas of study could be carried out in satellites or space probes from which specimens under study could be recovered.

More specifically, fundamental experiments on living organisms in the satellite environment or in other types of space vehicles and stations should be conducted along the following general lines:

Animal navigation and orientation; mitosis and embryology; plant morphogenesis; geotropic response of plants to altered gravitational fields; biological rhythms and cycles; altered gravitational effects on blood circulation in animals; vestibular physiology; neuropharmacology—effects of tranquilizers, motion sickness drugs, etc.; effects of cosmic radiation; tolerance limits for combined stresses; physiological and psychological deterioration; and effects of acceleration and deceleration.

There has been considerable speculation about the possibility of the existence of extraterrestrial life forms. The debate ranges from whether or not life exists on Mars and Venus, and, if so, in what form, to whether or not spores and similar life forms can survive the rigors of interplanetary space. Investigations of these topics must for the most part await observations which can be made on direct samples and studied in space laboratories of the future. It is conceivable, however, that, with proper and specialized instrumentation and remote sampling techniques, it may be possible to obtain evidence of primitive or complex organic material without the presence of a scientist and a laboratory in the sample area. Elaborate instrumentation and the recovery of records, or advanced telemetering techniques, could provide information about the nature of biochemicals on the planets.

PROGRAM

The program in biosciences is still being formulated. Immediate steps include a series of discussions with leading bioscientists to firm up important initial lines of attack.

This photo, purportedly the first of a Russian space rocket (probably the Sputnik III launching vehicle), appeared in the March issue of the Hungarian publication *Elet es Tudomany.*

The Soviet astronautical program

A three-phase plan, calling for simultaneous satellite experiments, lunar exploration, and investigation of the planets, may produce a Russian astronaut by the end of 1960 and see the insignia of the U.S.S.R. planted on the moon by 1967, the 50th anniversary of Communist power

F. J. Krieger, a physical scientist with Rand Corp., is one of the country's top authorities on Soviet astronautical activities. Author of two previous articles on this subject for ASTRONAUTICS (November 1958, and April 1959), Dr. Krieger has been with Rand since its formation in 1945, his fields of research including the chemistry and physics of rocketry and astronautics, and the science capabilities of the Soviet Union. He was editor of the now-famous Rand "Casebook on Soviet Astronautics" and is the author of "Behind the Sputniks," a book based on the casebook.

This article is based on a presentation made by Dr. Krieger at a panel discussion on the Past, Present, and Future of Space Investigation at the National Telemetering Conference in Denver in May (see page 64).

By F. J. Krieger
THE RAND CORP., SANTA MONICA, CALIF.

THERE can be little doubt at this point that Soviet space exploration is advancing rapidly according to a logical and well-ordered plan. The three Sputniks and Mechta, each representing a step forward in a progression of astronautical achievements, offer ample evidence of the existence of such a program.

The Soviet regime is fanatically dedicated to the proposition that Soviet man will be first in space, first on the moon, and first in interplanetary communications. The implementation of this proposition probably began sometime in 1951, when, allegedly, Soviet scientists successfully recovered by means of a parachute their first canine stratospheric rocket passenger. Soviet achievements since that time provide tangible evidence of current capability for lunar rockets, planetary probes and, possibly, lunar satellites.

Once Soviet scientists have solved the complex interdisciplinary problems associated with placing man in space and successfully recovering him—which they may very well do before the end of 1960—other technological advances in the conquest of space will follow as rapidly as the nation's economy will permit.

The era of manned space exploration will begin soon thereafter, and Soviet astronauts will probably plant the insignia of the U.S.S.R. on the moon by 1967, the 50th anniversary of Communist power and propaganda.

The Soviet astronautical program (discussed briefly in "Behind the Red Satellites," page 32, November 1958, ASTRONAUTICS) has been brought into focus in an article by a Prof. G. V. Petrovich in the March 1959 issue of *Vestnik Akademii* (CONTINUED ON PAGE 78)

Antennas for space vehicles

New concepts for antennas, such as the spherical equiangular spiral, promise to extend space communication range greatly

By Maurice G. Chatelain

CONVAIR-ASTRONAUTICS, DIVISION OF GENERAL DYNAMICS CORP., SAN DIEGO, CALIF.

AS THE range and velocity of space vehicles increase, space communication will become more and more difficult. In theory transmitters have sufficient power and receivers sufficient amplification to extend radio communication over interplanetary distances. But in practice transmitting power is limited by weight and receiver amplification by noise, so that achieving interplanetary radio communication becomes a major engineering problem.

One of the best ways to improve range in space communication is to increase antenna efficiency.

Transmitting power in a space vehicle can be obtained from several sources—chemical, solar, or nuclear. We can obtain approximately 10 whr per lb for a few months with a chemical battery, 1 whr per lb for about 10 years with a solar battery, and 700 whr per lb for about three years with a nuclear battery. In the near future, space vehicles will probably be powered with thermonuclear fusion, and the new science of magnetohydrodynamics will provide us with a weightless and almost unlimited source of power. But at the present time, with the sources of power available, we are still limited by weight.

Amplification in the receiver is limited by noise, which is a function of temperature and information bandwidth. Noise can be attenuated by cooling the receiver or by maser amplification techniques. It can also be attenuated by reducing the information bandwidth to a minimum.

Born in Paris, France, in 1909, Maurice G. Chatelain studied mathematics and physics at the Univ. of Paris, where he received an M.S. in electrical engineering in 1931. For 25 years he engaged in electronics research and development. During WW II, he directed a radio network for the French Air Force. Then, in 1955, he came to this country and joined the staff of Convair-Astronautics Antenna Research Lab. He is a member of ARS, the American Institute of Physics, and IRE.

Human Voice Requires 3-kc Bandwidth

Television requires a bandwidth of 3 mc, human voice 3 kc, and telemetering about 30 cps. During an interplanetary flight, there is plenty of time and little information to transmit. Consequently, the rate of information can probably be limited to a few cycles per second, which would considerably improve the noise level.

External noise, or interference, is an antenna problem. Antennas can be designed to eliminate all kinds of interference except those coming from the transmission path and having the same frequency and polarization as the transmitted radio signal. Unfortunately, in space communication, frequency and polarization cannot be considered as constant values.

In the design of an antenna, we have to consider the transmitting frequency, the polarization, and the power gain.

The choice of a transmitting frequency is not a simple problem.

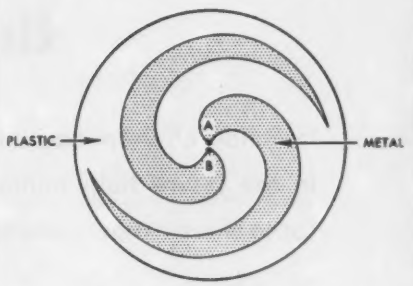
We know that below 20 mc radio waves are reflected by the ionosphere and that above 20 kmc they are absorbed by the atmosphere. For earth-to-space communications, then, we are limited by these two values. Radar echoes obtained from the moon between 30 and 3000 mc give us a pretty good idea of the best frequency range. For space-to-space communications, however, it is possible to use much lower and much higher frequencies.

Before the advent of Sputniks, Explorers, and Vanguards, we used to consider the frequency of a radio wave as a fixed value, the same in transmitter and receiver. But with the earth satellites, we met the Doppler effect problem, frequency shift caused by relative velocity, which, to be true, was not serious. Doppler effect was even very useful in calculating the orbit and velocity of the satellite.

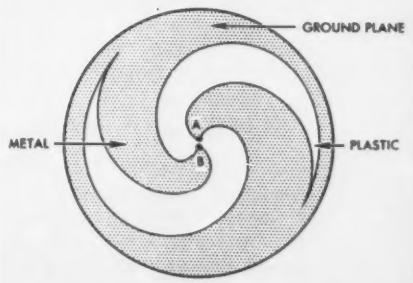
But in interplanetary travel, the problem will be different. We are trying to send a rocket probe around the moon, and we will try to send one around Mars in the next few years. These projects would be worthless if the space vehicles could not send data back to the earth. But at that time, a tremendous velocity, increasing during the first part and decreasing during the second part of the trip, will be required. The relative velocity of the vehicle with reference to the earth—and hence the Doppler shift—will change considerably during the whole duration of the trip, and thus make necessary very wideband antennas.

The relative attitude of the space vehicle to the earth will be difficult to know and to keep, and the relative position of the transmitting and receiving antennas, hence the polarization, will be unknown. Furthermore, with some types of antennas, helixes for example, the polarization depends on the relation between the wavelength and the antenna dimensions. For certain fixed antenna dimensions, polarization is a function of frequency; and we shall see that in space frequency is a function (CONTINUED ON PAGE 120)

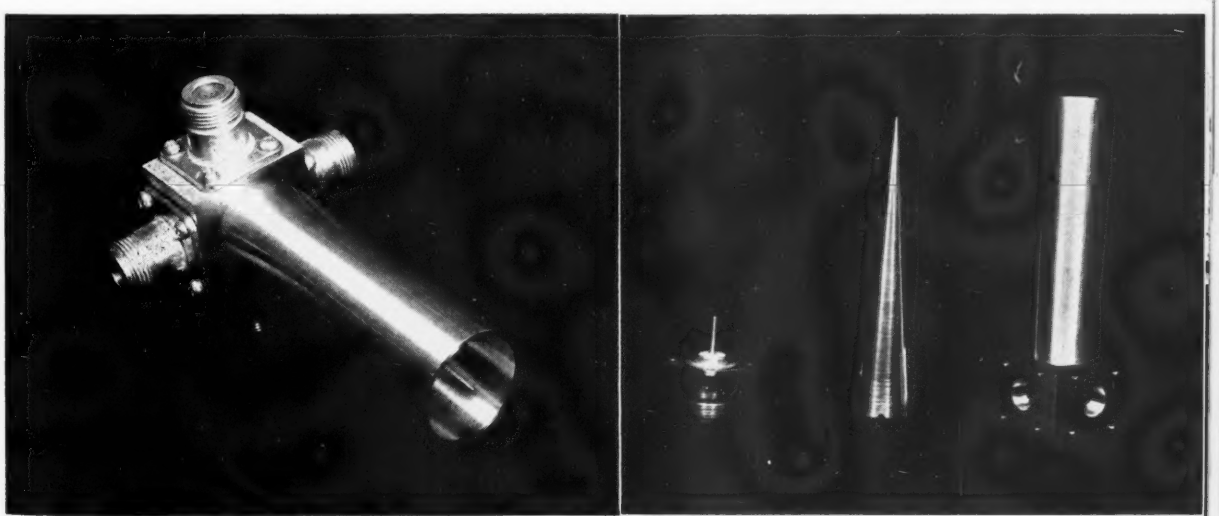
Spiral Antenna Forms



DIPOLE SPIRAL ANTENNA



SLOT SPIRAL ANTENNA
BOTH ANTENNAS ARE FED BETWEEN A AND B



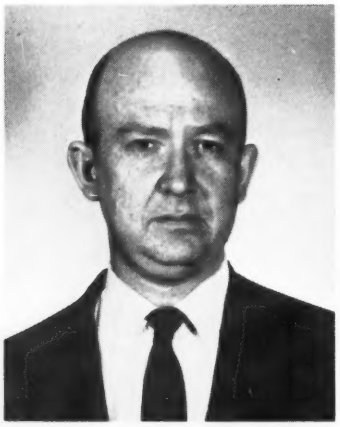
Recent research has produced omnipolarization antennas with 3-to-1 bandwidth (e.g., 3 to 9 kmc) such as this one with a conical ridge in a circular waveguide, shown assembled (left) and disassembled (right).

Artificial modification of the upper atmosphere

Injection of chemicals into the upper atmosphere with rockets may in the future help minimize extremes in the sun's influence on the ionosphere, and completely elucidate upper-atmosphere structure

By Murray Zelikoff

GEOPHYSICS CORPORATION OF AMERICA, BOSTON, MASS.



Murray Zelikoff is currently vice-president and head of the Aeronomy Div. of Geophysics Corporation of America, where he is engaged in research on the physics of the upper atmosphere. Before joining GCA, he was chief of the Air Force Cambridge Research Center Photochemistry Laboratory, and engaged in research on the atmospheres of the earth and other planets. A chemist by education, having received a Ph.D. in physical chemistry from New York Univ., he has also been active in rocket research for many years.

SINCE the early upper-atmosphere contamination experiments in 1955 and 1956, the release of chemical vapors from rockets has developed into a very useful research tool. Practical applicants have been slow in coming, largely due to the huge cost of rocket vehicles. In what follows, we shall review briefly the progress made in both research and application, and attempt to point out the direction of future work.

The first successful contamination experiment was performed in October 1955, by the release of 3 kg of metallic sodium vapor from an Aerobee rocket between 50 and 115 km. Enhanced sodium emission was observed from the ground visually, photometrically, and spectrographically during twilight. The emission faded gradually as the cloud was obscured by the earth's shadow, and thus showed that the twilight sodium emission is a resonance effect caused by solar radiation.

Since this work, numerous other sodium experiments have been carried out both at night and at twilight. In general, it can be stated that the resonance effect at twilight is replaced by a chemiluminescent effect at night; that is, sodium reacts with atmospheric molecules and atoms to produce excited sodium which then radiates.

A possible mechanism is as follows:

$$(1)\ Na + O_2 + M \longrightarrow NaO_2 + M$$
$$(2)\ NaO_2 + 0 \longrightarrow NaO_2 + O_2 \textit{ or}$$
$$(3)\ NaO_2 + H \longrightarrow NaH + O_2$$
$$(4)\ NaO + O \longrightarrow Na(^2P) + O_2 \textit{ or}$$
$$(5)\ NaH + O \longrightarrow Na(^2P) + OH$$

In several night experiments, strong sodium emission was observed at 140 km and above. Since this cannot be explained by (1–5) above (three-body processes are improbable above about 100 km), reaction of sodium with metastable atomic nitrogen is suggested as a possibility. Strong luminescence up to 200 km is still unexplained, although it suggests high-atmospheric temperatures or the presence of high-energy particles.

As a practical, as well as research (CONTINUED ON PAGE 118)

On Portola's ground

The 1959 ARS Semi-Annual Meeting held in San Diego brought a major outburst of papers and discussion on the groundwork for spaceflight

IN ITS 1959 Semi-Annual Meeting and Astronautical Exposition, held last month at the El Cortez Hotel in San Diego, ARS registered the full impact of the space age. The Semi-Annual Meeting produced 26 sessions and over 115 papers, which may be contrasted with the 11 sessions and something less than 50 papers of a year ago. This great increase of sessions and papers, as might be expected, reflects a burgeoning space technology and, as important for the Society, the strength ARS has gained, through its many new technical committees, for eliciting and organizing the presentation of important thinking and work in the multifaceted domain of astronautics.

Sessions at the Semi-Annual Meeting maintained the continuity of long-standing discussion on liquid and solid propellants, combustion, thermostructural materials, ballistics, telemetering, space law, guidance, research rockets, ramjets, missile systems, etc.; extended the 1958 Annual Meeting's focus on man-in-space plans and problems, human factors, nuclear and other advanced propulsion schemes, and auxiliary power supplies; and gave major representation to select areas of growing interest and interdisciplinary importance, such as astronomy from a space platform, microminiaturization, hypersonics, upper-atmosphere studies, and logistics and operations.

It would be near impossible to do justice to the Semi-Annual Meeting papers in this brief space, but a few comments may suggest their great variety and interest.

On a fitting note, the (CONTINUED ON PAGE 112)

Calculated Chemical vs. Experimental Rocket Engine Space Heating Rates

Propellants	Pc, atm	Space heating rate, Btu/ft³/hr Ex. Engine	Calculated
n-Heptane-Liq O_2	18.4	7.1×10^8	4×10^{14}
Liq NH_3-Liq O_2	10.9	3.9×10^8	2×10^{12}
Gas H_2-Liq O_2	20.4	8.4×10^8	2×10^{15}
Gas H_2-Liq F_2	25.2	8.5×10^8	7×10^{17}

* Value for iso-octane fuel

Space Power Requirements for NASA Missions

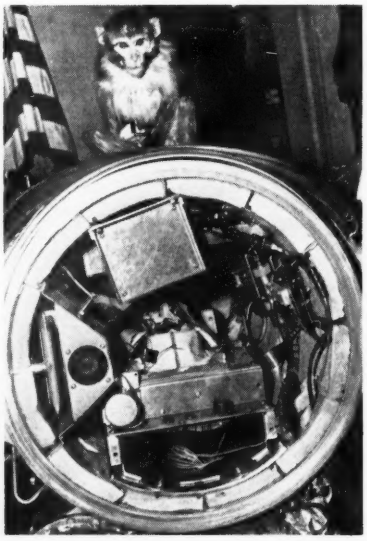
Payload	Date	Mission	Duration of Exploration	Power Avg	Power Peak
1	July '60	Circumlunar	40 hr	23	34
2, 3	Oct '60	Escape toward Mars	6 mos	36.2	47.5
4, 5	Jan '61	Escape toward Venus	6 mos	34.2	45.5
6	Sept '61	Out of ecliptic	6 mos	26.5	26.5
7	April '62	Lunar satellite	1 mo	46.2	61.5
8a, 9a	Aug, Sept '62	Venus satellite	2–3 mos	327.2	342.5
8b, 9b	Aug, Sept '62	Venus entry	6 mos*	—	59.5
10, 11	Nov, Dec '62	Mars near-miss	6 mos	44.2	59.5
12	June '63	Circumlunar and return	—	—	—
13, 14	? '63	Lunar soft landing	1 mo	329.5	354.5
15, 16	Mar, April '64	Venus landing	1 mo	380	395

* Plus 24-hr landing period.

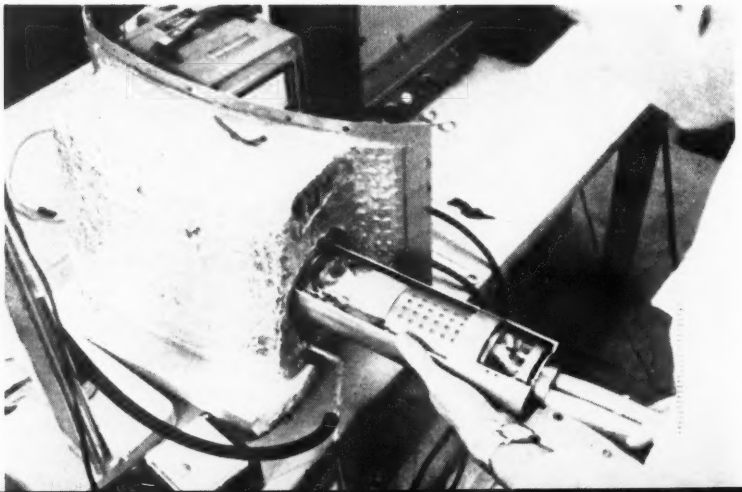
At left, nose cone is recovered by Navy ship Kiowa. At right, monkeys pose on Kiowa after spaceflight. The monkeys sustained some 9 min of weightlessness and over 6-g deceleration on re-entry.

Able, Baker — Astronauts

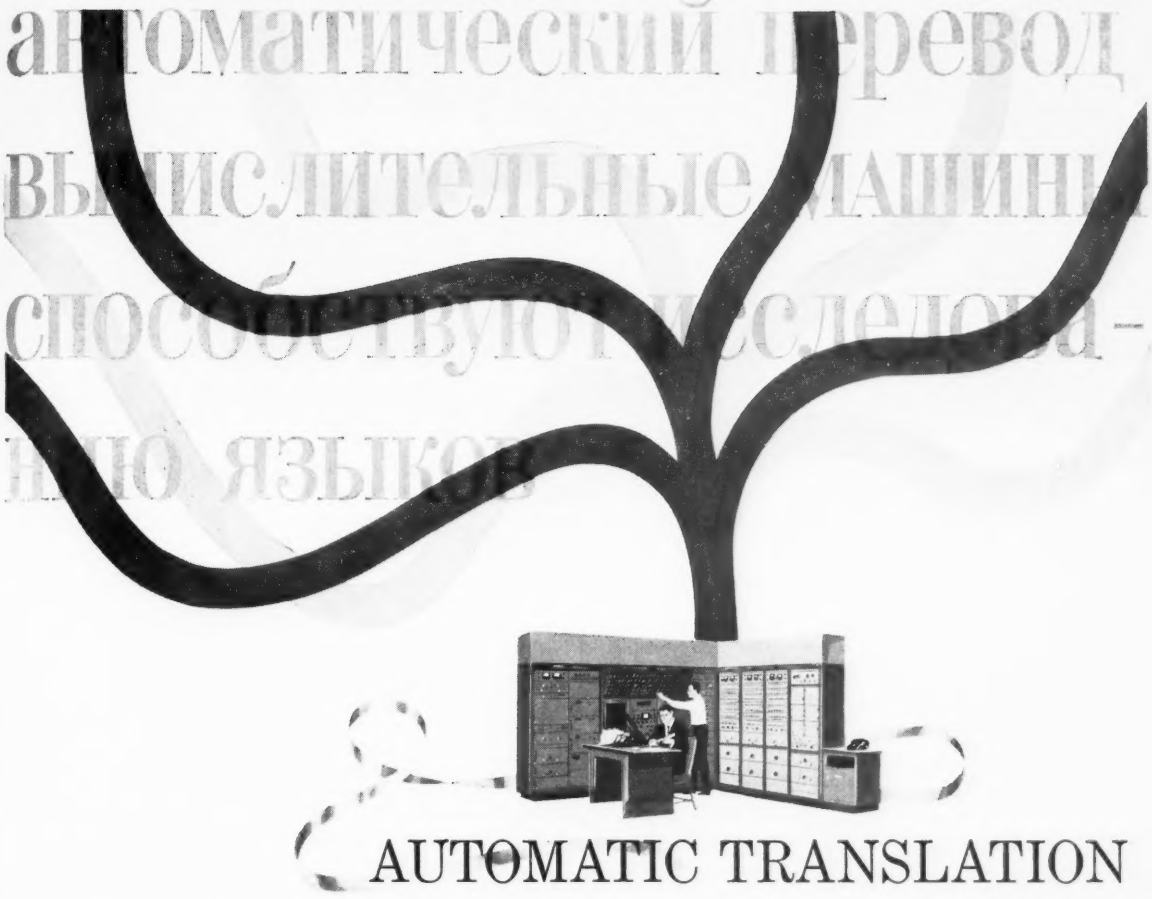
NASA and the Army combined talents May 28 to return the first animals—monkeys Able and Baker—alive from a spaceflight



Riding in a 250-lb capsule in the nose cone of a Jupiter missile, the monkeys reached an altitude of 300 miles in a 1500-mile trajectory, which saw them land and picked up by a Navy recovery ship in the Atlantic near Antigua Island, as shown above. At left, Siegfried Gerathewohl of ABMA looks over test monkey in Able's spacesuit, which fitted in Jupiter nose cone compartment, as shown at right, with Able looking on after flight. Compartment reached maximum temperature of 84 F.



Baker, tiny South American squirrel monkey, rode in this life-support cylinder, shown being placed in compartment similar to one used in the experiment. Monkey, cylinder and life-support system weighed 29½ lb.



AUTOMATIC TRANSLATION

Computing machines aid language research at Ramo-Wooldridge

To formulate rules for automatic language translation is an enormously subtle and complex project. Yet significant progress is being made. During the past year of research at Ramo-Wooldridge over 60,000 words of Russian text have been translated and analyzed using an electronic computer. From the beginning several hundred syntactic and semantic rules have been used to remove ambiguities that are otherwise present in "word for word" translation. Our present computer program for automatic translation is a considerable improvement over earlier attempts.

Apart from the question of translation itself, electronic computers are invaluable for language research. The expansion of existing knowledge of the rules of language, through statistical analysis, is made practical by mechanized procedures. A clear symbiosis between linguistics and computer technology has emerged.

Automatic translation research is one of many R-W activities addressed to problems of communication of scientific information. These problems are increasing at an accelerating pace. In this area, as in others, scientists and engineers find at Ramo-Wooldridge challenging career opportunities in fields important to the advance of human knowledge. *The areas of activity listed below are those in which R-W is now engaged and in which openings also exist:*

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Measuring Upper Air Structure

(CONTINUED FROM PAGE 29)

modate the range of five orders of magnitude of pressure encountered in passing through the atmosphere to the peak of the rocket trajectory.

Conversion of the pressures measured on the cone to ambient pressure, temperature, and density may be accomplished in two ways. The supersonic pitot-tube equation may be used in the following form to calculate ambient density from the ram pressure (P) and the velocity (V), which is known from tracking, if V is large: $\rho = 1.166 \times 10^3 \, P/V^2 \, kg/m^3$.

In a more elaborate treatment, the Mach number (m) of the flow around the cone may be calculated from the ratio of ram pressure to cone-wall pressure. The velocity (V) of the missile being known, the ambient temperature (T) is calculated from $T = M \gamma R (V/m)^2$ where R is the universal gas constant, γ the ratio of specific heats, and M the molecular weight.

F. L. Bartman of the Univ. of Michigan and W. G. Stroud of the U.S. Army Signal Research and Development Laboratories measured temperatures and winds by the grenade method in 10 Aerobee flights at Fort Churchill. In this experiment, 19 high-explosive grenades are carried aloft as a package and ejected and detonated one by one at regular intervals between 30 and 90 km, as indicated in the figure on page 29. A Doppler tracking system gives the positions of the bursts in space, while an array of microphones receives the acoustical waves on the ground. From the times of arrival of the sound on the ground, the temperatures in layers bounded by grenades are measured; and from the acoustical angles of arrival, the wind vectors in the layers may be calculated. Although the grenade experiment is not as simple as some others, its complexity was justified by the expectation of taking the wind measurements, the only extensive ones being made up to 90 km. In fact, the Fort Churchill grenade firings were marked by an unusually high percentage of data recovery.

During the IGY, the author was engaged in a program for determining upper-air density by measuring the drag on falling spheres. In this program, under the sponsorship of AFCRC, 10 Nike-Cajun's were used to launch 7-in.-diam spheres containing an accelerometer for measuring, in any direction, the drag acceleration. One such sphere is shown on page 29. A tiny telemetry transmitter was carried to report the measurements to the ground. Knowing the mass, cross-sectional area, and coefficient of drag of the sphere, the ambient air density can be calculated.

An outstanding feature of this technique is that the sphere measures its own trajectory, thus eliminating the need for a tracking array. With telemetering and meteorological balloons as the only supporting gear required, the sphere experiment is suitable for operation away from an elaborate ground base. Just prior to IGY, five spheres were launched from the deck of the USS Rushmore (LSD-14) in the North Atlantic and Davis Strait. Four additional firings were carried out at Fort Churchill during the IGY.

Russian Work

It may be wondered what comparable work the Russians are doing. The Russian "meteorological rocket" and the instrumentation used for measurements at medium altitudes have been described in various places. The rocket is roughly the equivalent of our own Aerobee. A standard instrument package, illustrated on page 29, has been developed and is often re-used after parachute recovery. A 1-in.-diam, 30-in. probe at the forward end of its ogival nose cone carries, at the very tip, miniature Pirani gauges to measure ambient pressure from 30 to 85 km. Ten inches from the bottom of the probe, openings lead to tubes which communicate with diaphragm pressure gauges in the nose cone proper. These cover the range from ground level to 30 km. At the center of the slender probe, a series of four external tungstenwire (40 μ-diam) resistance thermometers measure ambient air temperature directly. Four bolometers and a resistance thermometer mounted on the spire measure solar radiation and probe temperature for correcting the readings of the gauges, particularly the resistance thermometers. Other thermometers are used to correct the Pirani- and diaphragm-gauge readings.

The nose cone is ejected and its parachute deployed at 70 km on the upleg. A typical peak altitude is 85 km. The parachute is ineffective above 65 km and presumably corrections are made for the effects of the supersonic velocity just above this altitude. Below 65 km, velocities of 500 to 300 fps are encountered, and the gauges read nearly ambient conditions.

At the recent IGY meeting in Moscow, E. G. Shvidkovsky reported on the results of Soviet structure measurements at medium altitudes. Fifteen pre-IGY measurements at all seasons of the year yielded an average atmosphere to 80 km at about the latitude of Moscow (56 deg North). These are consistent with similar U.S. results at 32 deg North. Twelve flights during IGY were reported to an altitude of only 50 km. Since the same instruments were used in these flights as in earlier ones with the meteorological rocket, it may be that eventually results to 80 km will be published. Shvidkovsky said that tracking of the rocket is required to obtain the higher altitude data, but he did not indicate whether the IGY rockets were tracked.

In any case, many significant measurements were reported. Four flights were carried out on Heiss Island (82 deg North) in Franz Josef Land, much farther north than the U.S. flights. Eight flights were carried out in the middle latitudes ($\sim$ 56 deg North), and two of these, made during the winter, are of interest for comparison with sphere flights which give winter results at Fort Churchill (59 deg North) and the grenade flights which covered both summer and winter at Fort Churchill.

The graph on page 29 compares U.S. and Russian measurements. Allowing for nominal differences in time and location, Russian and U.S. results are in good agreement. It will be interesting to note whether the warming of the Arctic winter atmosphere above 70 km, a phenomenon shown in the U.S. measurements and not detected at temperate latitudes, is confirmed by the Russian technique.

The entire 18-month IGY effort in measuring upper-air structure consisted of something under 200 rockets, or about the same as the number of balloons which go to the 20–30 km region in one day. Thus the kind of synoptic survey available to tropospheric meteorology is as yet beyond the reach of rockets.

Nevertheless, the increased rocket effort during IGY over that in previous years is a big step forward and has already yielded important results. Among the more interesting of these is the wide variability of Arctic densities (see page 24 of this issue) compared with Temperate Zone densities and the warming of the winter Arctic atmosphere at 80 km.

New Memory and Switching Device

Bell Telephone Labs has developed a magnetic memory and switching device, known as Laddic and cut in the shape of a ladder, that can operate at speeds essentially limited only by the current drives available and which has achieved switching speeds of a few tenths of a microsecond and repetition rates of a few hundred kilocycles.

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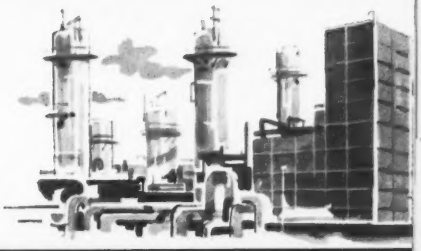
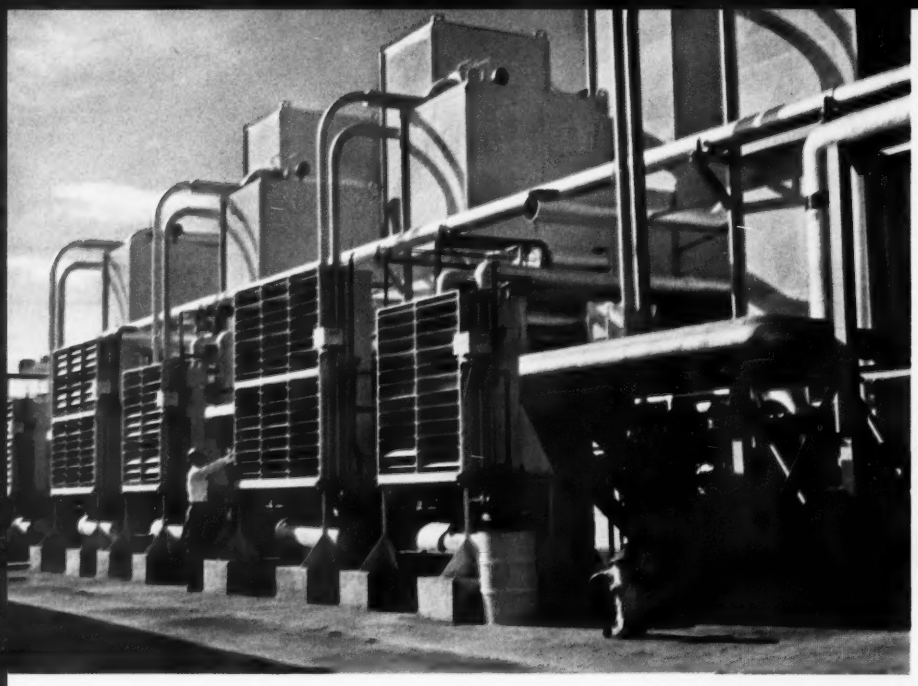
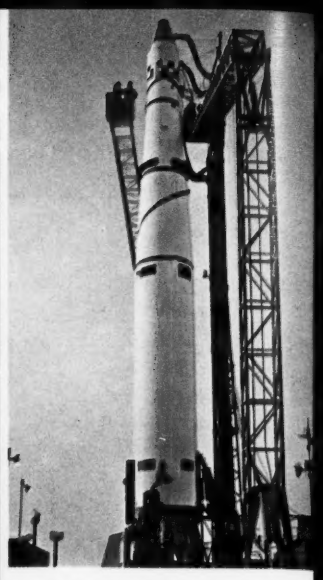






Liquefied gases from Air Products equipment supply all major U.S. missiles.

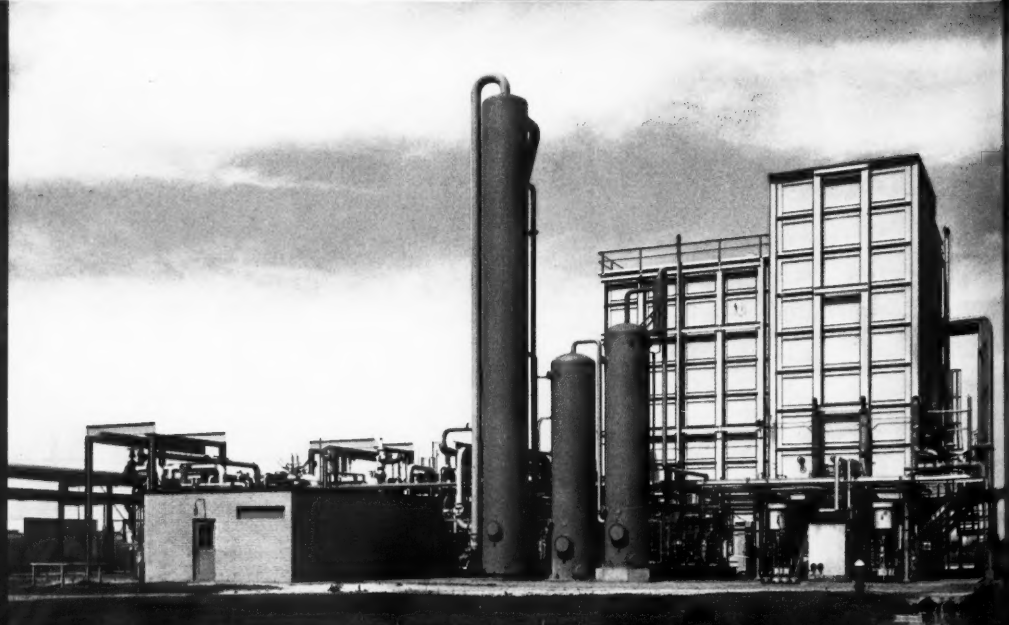
HOW THE MILITARY SERVICES use Air Products CAPACITY

Large-scale low-temperature systems, ultra pure gases and liquids, and a broad range of specialized cryogenic "hardware" are supplied by Air Products to the military. When large quantities of liquefied gases were needed for rocket engine development and missile testing, Air Products quickly designed, manufactured and put on stream complete production facilities. Typical facilities paid for themselves in less than a year's time. Air Products also provides a broad line of portable air separators for field and shipboard use . . . and has advanced the development of exotic fuels. And, Air Products produces advanced design liquefied-gas pumps, cryogenic storage and transfer systems, electronic cooling devices and refrigeration and distillation equipment for military uses.

YOU will find here tangible evidence of a growing technology. Applying "Cryogenics" (the science of low temperatures) and engineering broad new routes to low-cost, high-purity industrial gases is the main business of Air Products.

Air Products combines original research knowledge with engineering and manufacturing capabilities and substantial operating experience. These integrated activities have

These companies and many others are the beneficiaries of major facilities provided by Air Products:
Acme Steel • Bethlehem Steel • Brazilian National Steel • [illegible] • Dow Chemical • du Pont • Grace Chemical • Great Lakes [illegible]



Petrochemical plants use Air Products equipment in feedstock preparation and product purification.

HOW THE STEEL INDUSTRY
uses Air Products CAPACITY

n the blast furnace, the open hearth and the new converter processes — Air Products oxygen efficiently increases steel mill capacity. Annealing itrogen and other gases are also provided on a w-cost tonnage basis.

Air Products' complete gas supply systems are nstalled at steel mills without capital investment r operating worries on the part of the users. Continuity and reliability of supply are assured. On-site facilities pioneered by Air Products educed the cost of oxygen 80% in 12 years — ransforming oxygen from a costly chemical to practical working utility.

Further progress marks on-the-job development ork now continuing around the clock at major teelmaking facilities. Entirely new metallurgical echniques . . . and new profits . . . are available hrough Air Products.

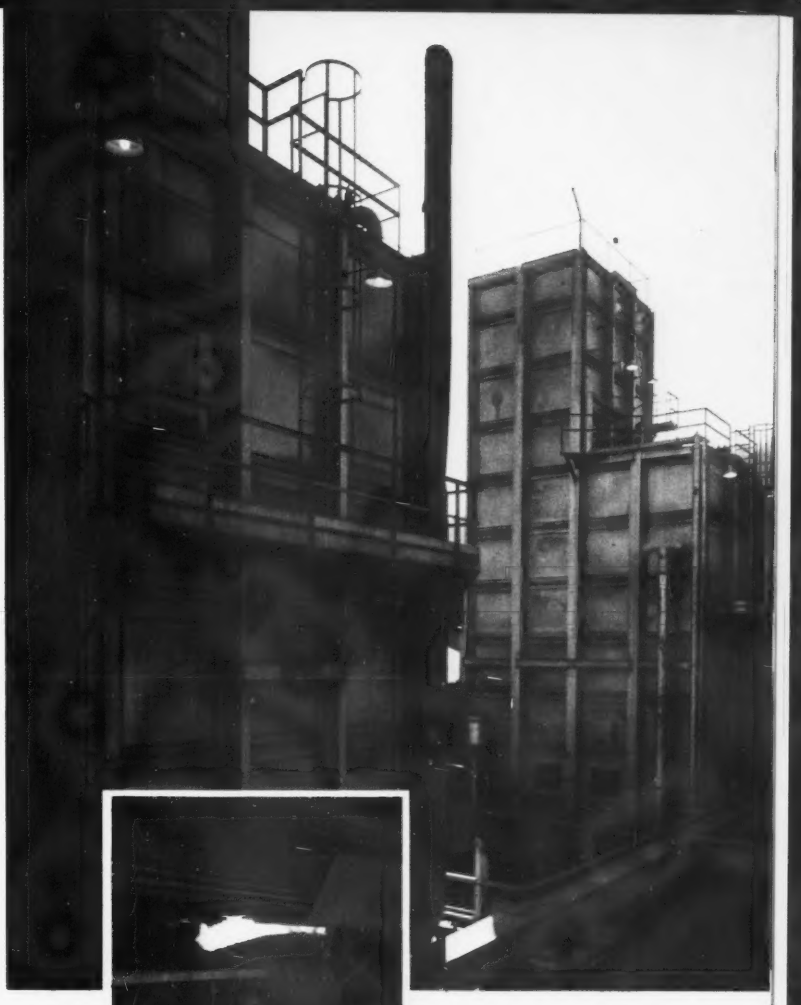
helped provide many Air Products customers with distinct competitive advantages.

Air Products is the world's leader in APPLIED CRYOGENICS — the practical and profitable use of low-temperature science for industry.

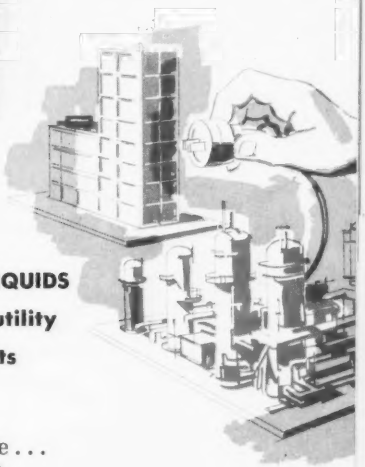
Perhaps this CAPACITY can help solve your problems — in cryogenics, in industrial gas supply systems, or in some new area where "ground rules" are yet to be established.

nce o Cryo- tures y-cost busi- search actur- atin have

ciari Jones & Laughlin Steel · Osaka Oxygen · Spencer Chemical Sun Oil · U.S. Government - All major research and defense mpanies · United States Steel · Venezuelan Ministry of nes · Weirton Steel.



Air Products pipeline oxygen serves the Basic Oxygen Furnace Process.



HOW THE CHEMICAL INDUSTRY
uses Air Products CAPACITY

Air Products low-temperature systems permit many modern chemical plants to improve operating efficiency and end-product quality — and to develop new processes and products. This results from the ready availability of low-cost tonnage quantities of oxygen, nitrogen, hydrogen, ammonia and methanol syn-gas, carbon monoxide and hydrocarbons such as purified methane, acetylene and ethylene. Low-temperature separations of gaseous mixtures now make it practical to recover valuable components from natural gas, refinery off-gases, coke-oven gas and other "waste" gases. The versatility of cryogenics—as applied by Air Products—works profitably for the chemical industry today . . . offers unparalleled future opportunity in this fast-growing industry.

HIGH PURITY GASES AND LIQUIDS
—available like any other utility
with the help of Air Products
CAPACITY

. . . The supply is dependable . . . the price guaranteed . . . with Air Products on the job.

Air Products
...INCORPORATED

Perhaps you, too, can profit from

Air Products CAPACITY*

To find the new opportunities Applied Cryogenics may offer in the manufacture, separation and purification of Industrial Gases.

To provide integrated research, engineering, manufacture and operation . . . complete services under a single responsibility.

To forecast accurately and guarantee total cost, superior performance and reliability.

To put entire gas supply complexes to work for you *without capital investment on your part.*

Air Products CAPACITY has helped our customers to step out ahead of competition in familiar fields . . . to open up entirely new areas of opportunity through new products or processes. A letter or telephone call will put Air Products CAPACITY to work for you.

Information is available on:

superconductivity
frozen free radicals
biological preservation
environmental control
low-temperature catalytic reactions
infrared detection
masers

purification and liquefaction of:

argon
carbon monoxide
ethylene
fluorine
helium
hydrogen
krypton
methane
neon
nitrogen
nitrogen trifluoride
oxygen
oxygen difluoride
ozone
xenon

Air Products . . . INCORPORATED
ALLENTOWN, PENNSYLVANIA

Air Products (Great Britain) Ltd., London
Air Products, S. A., Caracas
Dynamic Research, Inc., Los Angeles

Sun and Upper Atmosphere

(CONTINUED FROM PAGE 22)

perature of about half a million K. That such temperatures must exist in the solar corona was realized by astrophysicists as far back as 1938, but the intensities observed by means of rockets are far higher than was suspected. The maximum of the X-ray emission falls in the neighborhood of about 50 Å At shorter wavelengths, below 20 Å, the emission is highly variable over periods of weeks or even days. Between 10 and 20 Å the emission has a spectral distribution typical of a higher temperature, perhaps a two-million-K thermal source. On the infrequent occasions of solar flares, still shorter X-ray wavelengths are emitted, down to 1 or 2 Å, and the emission spectrum is characteristic of a thermal source at temperatures perhaps as high as 10 million K.

Practically all our knowledge of the ionosphere before rocket measurements was based on radio soundings. A pulse of radio waves entering a cloud of electrons is reflected when the density of electrons reaches a critical value proportional to the square of the frequency. The time required for the pulse to travel to the ionosphere and back to ground is a measure of the height of the reflecting region. At certain critical frequencies, there appear abrupt discontinuities in reflection heights, as though the electron density were distributed in several well-defined layers. These layers were named E, F_1, and F_2. In the lowest region, named D, the electron density is too small to reflect megacycle-per-second frequencies. The lower ionosphere normally acts as an absorbing region for these short waves and a good reflector for very long waves, such as the static generated by thunderstorms.

Rocket measurements have done away with the concept of discretely separated ionospheric layers. Instead, we now see the ionosphere as a continuum of ionization increasing steadily with altitude. In terms of our current knowledge of the solar spectrum of ionizing radiations, it is clear that the ionosphere cannot have abruptly bounded stratifications simply as the result of the interaction of solar radiation with a static atmosphere. Any abrupt discontinuities must be attributed to wind-shears. When the sun is quiet, the lowest level of the ionosphere, the D region, can be accounted for entirely in terms of the ionization of nitric oxide by the ultraviolet Lyman-α line of hydrogen. The X-ray emission from 10 to 100 Å contains enough energy to produce most of the E-region, and the ultraviolet line of singly ionized helium at 304 Å is capable of accounting for most F-region ionization.

At times of great solar activity, X-ray emissions from the sun are greatly enhanced. By far the most spectacular form of activity is the solar flare. The catastrophic magnitude of a solar flare can best be appreciated when it is viewed in the red light characteristic of excited hydrogen atoms in the chromosphere. In a matter of minutes, a local region of the solar surface increases tenfold in brightness and the flash spreads over hundreds of million of square miles. Simultaneously with the flash, the ionosphere becomes so dense in the D-region that broadcast frequencies are completely absorbed and communications disrupted. This condition is known as radio fadeout or blackout. Reception does not return to normal until the flare disappears, which may take half an hour to several hours depending on the size of the flare.

Results of Program

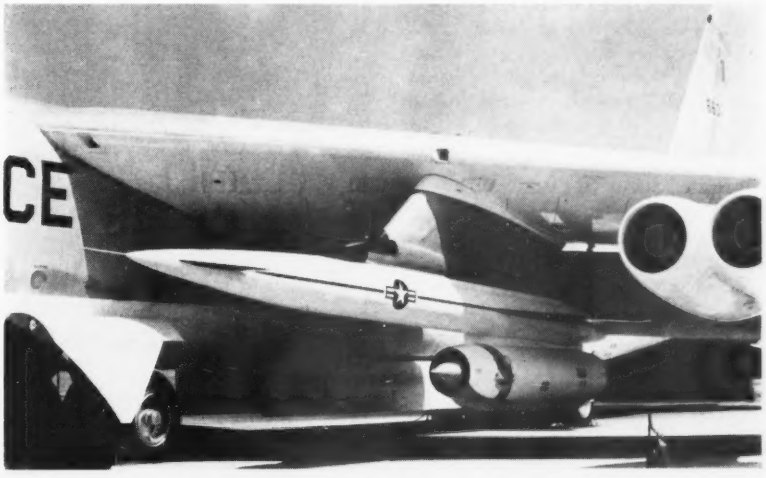
The results of the IGY solar flare program carried out by NRL show that the ionospheric effects accompanying a flare are the result of bright X-ray flashes. The ionization produced by these X-rays acting on the lowest portions of the ionosphere greatly enhance its absorbing properties.

Experiments at Fort Churchill indicated that polar blackouts were also associated with X-rays, but these X-rays appear to be produced by the electrons derived from the trapped radiation belt discovered by Van Allen's detectors in the Explorer satellites.

It is important to be able to compare directly the distribution of ionizing sources of radiation on the sun with visible phenomena. What is needed are photographs of the sun in Lyman-α, the helium resonance lines, X-rays, and other short wavelengths. However, the familiar techniques of photography in visible light are not at all applicable to photographing the sun in short wavelengths.

On March 13, 1959, the striking photograph of the sun shown on page 21 was made in the light of Lyman-α by a rocketborne camera. This camera, diagramed on page 21, was the result of four years of development at NRL by Tousey, Purcell, and Packer. Since this ultraviolet light is strongly absorbed by all materials, lenses could not be used and the whole camera had to be constructed with mirrors. These were not ordinary mirrors, however, but were diffraction gratings—parabolic mirror surfaces ruled with 15,000 lines to the inch. The rulings caused the intense visible light from the sun to be thrown out of the camera, leaving only the monochromatic Lyman-α radiation to form the solar image.

Ordinary film cannot be used to photograph the image because the



First Close-Up of AF Hound Dog

Close-up of North American's GAM-77 Hound Dog air-to-ground strategic missile shows how bird will be mounted under B-52 wing. Operational AF missile will have the same aerodynamic characteristics as this training and test model.

gelatine binder in the emulsion absorbs the extreme ultraviolet before it can reach the sensitive silver-halide grains. A special film containing almost no gelatine must be used. This is very fragile and care must be taken not to touch the surface, or the image will be wiped off.

Once in flight, it is still no small feat to guarantee taking good pictures, because the rocket is sure to be unstable, rolling, pitching, and yawing. Precise pointing is essential, as it is to any astronomical telescope. A complicated servo system, developed and built by physicists at the Univ. of Colorado, was necessary to keep the entire instrument pointed at the sun.

The photograph on page 21 shows this system mounted in the nose of the launching rocket. The instrument package contains both a spectrograph and the camera just described. The instrument package is recessed within the nose cone at the start of flight, and is then swung out to point at the sun at an altitude of about 100,000 ft. The entire nose section rotates about the long axis of the rocket, counter to its spin, and the instrument package is free to rock in trunnions. This two-axis rotation permits the instruments to hold on the sun despite rocket spin and yaw.

Sun Has Different Faces

The average person seems to think of the sun as a smooth yellowish disk occasionally marred by small dark blemishes called sunspots. The astronomer, however, finds that the sun has as many different faces as he can find wavelengths of radiation in which to observe it. In the red light of excited hydrogen, it shows fuzzy, lacy, bright areas called plages, and a turbulent, grainy surface. In calcium violet light, it shows a mottled surface that has been likened to the skin of an orange, with the plage regions showing even brighter.

With more refined techniques, we now see evidence of weather in different parts of the solar atmosphere, and can attempt to correlate changes in solar weather with our terrestrial ionospheric weather and even the local tropospheric weather. The Lyman-α picture clearly shows that the radiation is emitted from spots and patches over the solar surface, and this seems to be consistent with the observed wide range of variations and rapid changes in quality of radio propagation. When combined eventually with television techniques, ultraviolet cameras will permit us to photograph the sun routinely in the most important short-wave radiations and to obtain daily solar weather reports for predictions of terrestrial responses.

As for the night sky, NRL rocket experiments by T. A. Chubb, E. T. Byram, J. E. Kupperian Jr. and others have given us a strange and unexpected picture of the celestial sphere in invisible ultraviolet light (January 1959, ASTRONAUTICS, page 26). The most brilliant visible stars are missing. Instead the sky is diffused with a bright glow of ultraviolet Lyman-α radiation, characteristic of excited hydrogen atoms, and splotched with great ultraviolet luminescent clouds or nebulosities. The diffuse glow of Lyman-α which covers the entire night sky exceeds the intensity of all visible star light. It appears that the origin of this radiation is solar Lyman-α reflected back from space by neutral hydrogen atoms.

How the reflecting hydrogen is distributed in space is still not entirely clear. If the hydrogen is interplanetary, it is necessary that there be of the order of a few tenths of a neutral atom per cc spread over a distance of an astronomical unit (93 million miles). For every neutral atom, there must be of the order of 100 ionized atoms (protons) and electrons. If, instead, the hydrogen surrounds the earth in the form of a geo-corona extending perhaps to distances as far as the moon, then the density would on the average be 400 times as great.

Above 300 Mile

Above 300 miles, the ionization of the outer atmosphere and interplanetary space has been estimated from a variety of indirect measurements. Russian scientists recently completed a study of the zodiacal light in the night sky of the Libyan Desert which indicates that the light is produced primarily by scattering from fine cosmic dust rather than from gas. They set an upper limit of not more than 20–30 atoms and free electrons per cc on the gas density at the distance of the earth's orbit. These numbers are not inconsistent with the rocket results.

Radio whistlers, which are audio frequencies generated by lightning flashes, travel from one hemisphere to the other along magnetic lines of force arcing thousands of miles into space above the equator. To transmit these waves, space at a distance of several earth radii must contain about 600 electrons per cc. Over the course of a year, it is estimated that the sun evaporates as much as 100 million tons of hydrogen ions. At the distance of the earth, this amounts to about 100 particles per cc. The acceleration of comets' tails away from the sun is attributed to streams of gas from the sun carrying from a thousand to a hundred thousand particles per cc.

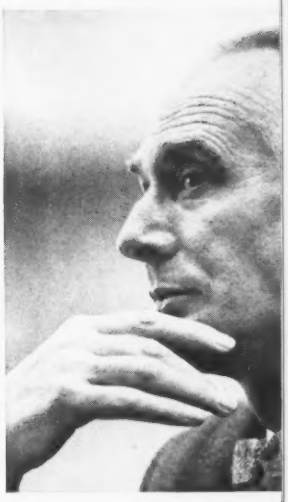
A knowledge of the distribution of hydrogen in the solar system is of fundamental importance to all theories of sun-earth relationships and the lifetime of charged particles caught in the Van Allen belts. NRL is planning several experiments which may help to settle this question of hydrogen distribution.

For example, it should be possible to map the change in overhead brightness of the hydrogen glow by means of a rocket traveling out to distances of 10 or 20 earth radii and from such data to derive the vertical distribution of hydrogen. Also, refined spectroscopic studies of the shape of the Lyman-α emission lines from the sun and from the night sky should provide important clues to the amount of hydrogen between the sun and the earth and the temperature of the interplanetary or geo-coronal gas.

Based on a paper presented at the ARS 1959 Semi-Annual Meeting and Astronautical Exposition held June 8–12 at the El Cortez Hotel, San Diego, Calif.

Giant Klystron for Long-Pulse Radar

Developed by Varian Associates under sponsorship of the Air Force, this giant klystron, measuring 12 ft long and weighing 900 lb, generates very high average power for long pulse radar.



WASP

THESE MEN DO ALMOST NOTHING BUT THINK

Unique new group helps Westinghouse anticipate and plan for future military needs

It's harder than ever to stay out front in defense.

Weapons systems are now fantastically complex. New innovations—like thermoelectricity and molecular electronics—threaten to make key subsystems obsolete overnight. New developments may suddenly reduce the tactical usefulness of a U. S. weapons system.

Westinghouse, like many other firms, has been concerned about how to meet this problem—and how to organize its many R&D and manufacturing operations to more effectively support America's increasingly complex defense needs. It seemed that the organization which had worked fine in the past simply wasn't adequate for anticipated future demands.

So things were completely reorganized in February, 1958. A new Defense Products Group was established, centralizing control of all defense-oriented activities within the company.

But a most interesting—and promising—part of this new organization, the new Westinghouse Advanced Systems Planning Group (now commonly called WASP), wasn't announced publicly until August.

This was a significant development. Since technology is moving faster than ever before, there's a real need to effectively anticipate what will be needed in 5 or 10 years. If this can be done, longer-lived defense systems can be developed more quickly and substantial sums can be saved. WASP should be able to provide the advance thinking needed by Westinghouse to meet this need.

Staffed with hand-picked engineers and scientists—specialists in electronics, outer space, atomic power, ASW, operations research, etc.—and headed by Allan Chilton (top center photo above), WASP operates on a unique charter: to concern itself primarily with

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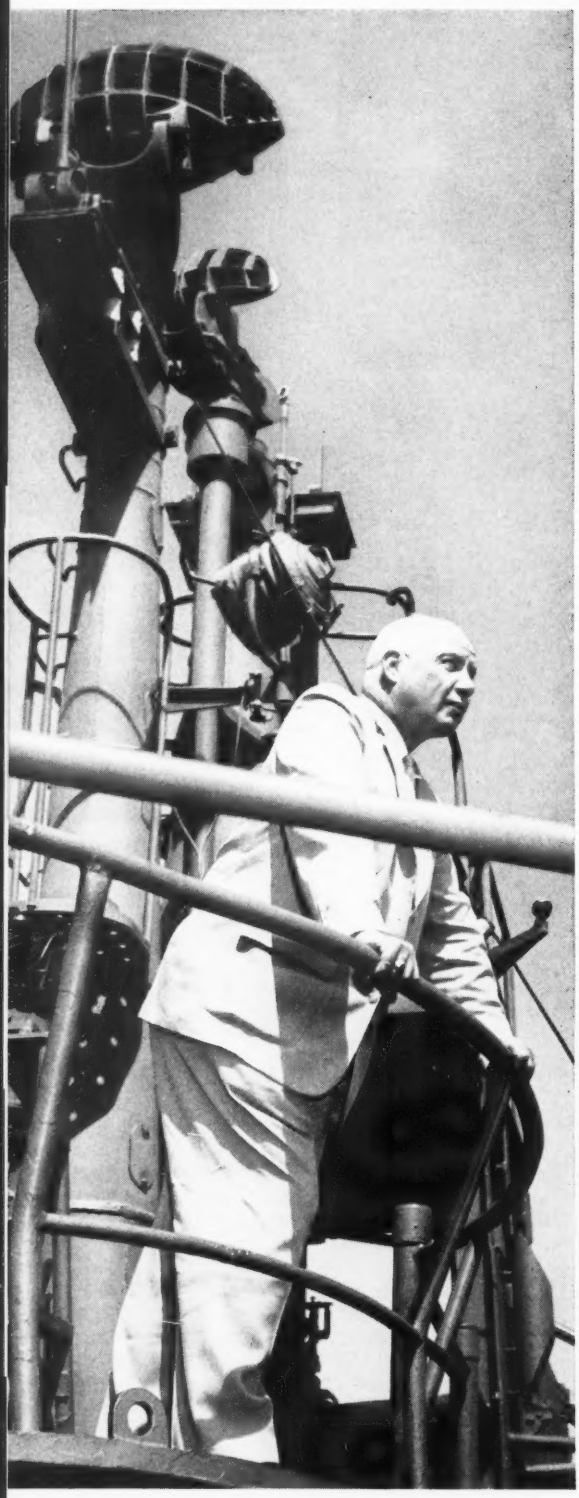
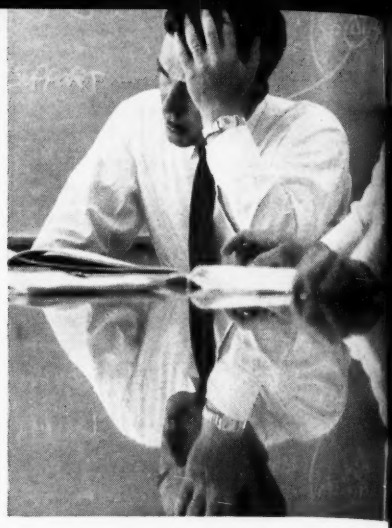


MATCHING NAVAL REQUIREMENTS with Westinghouse capabilities, Leonard Dow, a professional career specialist in naval strategy, tactics, and weapons systems, is associating advanced technology to future naval systems.

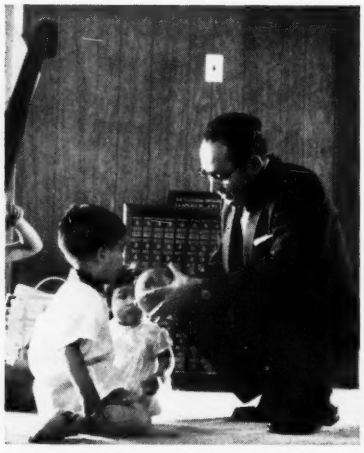


"The idea is sound, but how can we keep it from burning up? Present insulations won't work. How about ablative heat sinks? No—they won't work either in this case."

complete advanced weapons systems, to deal with the "whole" instead of "parts".

This is not just a "blue-sky thinking" assignment. Westinghouse believes future defense needs will be so complex that only a full-time team of specialists—like WASP—will be capable of the kind of conceptual planning and guidance needed.

There's another reason why defense planners will be interested in WASP. This new group gives them a single point of contact within one of America's largest and most versatile industrial firms to which they can take immediate and long-range defense problems. No longer will it be necessary for someone



". . son, it circles the earth at 18,000 miles an hour." Space consultant, K. Satyendra, a Ph.D. from India, keeps WASP and other company scientists abreast of space needs. He is an authority in mission, trajectory, and communication concepts.

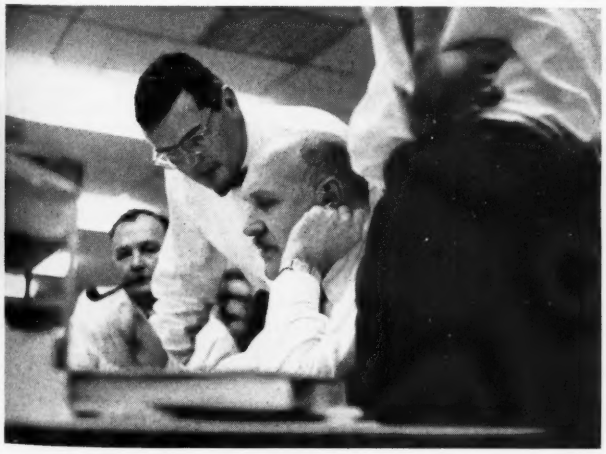
TOP ENGINEER AT WASP, Rein Kroon joined Westinghouse in 1931. Among other accomplishments, he headed the engineering group responsible for the design of the first American turbojet engine for aircraft.

"What's the best way to destroy an enemy reconnaissance satellite? Attack it from earth? Or from another satellite? How would we go about either method?"

to try to guess which Westinghouse division is best equipped to tackle a given job.

This is a bigger advantage than might be apparent. A newly-published capabilities chart*, for example, lists 29 different Westinghouse facilities and, for each, indicates specific study, design, or manufacturing capabilities in 33 different areas (infra-red, rocket powerplants, torpedoes, missile base equipment, etc.). This same chart lists 16 Westinghouse facilities which can handle system analysis and 7 capable of complete system management.

**Available to qualified individuals and firms upon request.*



"Could we deflect enemy ICBM's by sending them false signals at the time of launching? If so, could this be done from distant transmitters? Could this be done automatically from remote un-manned stations?"

MAN ON THE MOVE, Bill Robinson has his sights on tomorrow's systems and provides guidance for WASP in planning for future Department of Defense needs.

Westinghouse

DEFENSE PRODUCTS

1000 CONNECTICUT AVE., NW, WASHINGTON 6, D.C.

YOU CAN BE SURE... IF IT'S Westinghouse

ARS news

10 Technical Sessions Set for Propellant Thermodynamics and Handling Conference at Ohio State Univ.

To solve the engineering problems associated with the handling of today's high-energy and storable propellants, a good deal of basic physical, chemical, and thermodynamic data are required. The ARS Propellant Thermodynamics and Handling Conference, to be held at Ohio State Univ., Columbus, Ohio, July 20–22, will cover such problems in detail, while also discussing the advances which have taken place in the calculation and prediction of thermodynamic processes by computers.

The meeting, fourth in a series of such special ARS subject conferences this year, is sponsored by the ARS Propellants and Combustion Committee in cooperation with Battelle Memorial Institute and the Aeronautical Engineering Dept. of Ohio State. The ARS Columbus Section is in charge of meeting arrangements. Loren E. Bollinger of Ohio State and Alexis W. Lemmon Jr. of Battelle are the general co-chairmen of the conference.

Highlights of the meeting include 10 technical sessions, covering thermodynamic properties of propellants, handling of high-energy fuels, handling of fluorine, thermodynamics and combustion processes, rocket performance calculation techniques, combustion, propellant handling, and performance analysis and thermodynamics; two luncheons and a banquet, with Rear Adm. John E. Clark (USN), ARPA deputy director, scheduled to be the banquet speaker; and field trips to the Janitrol Aircraft Div. of Surface Combustion Corp., the Aerodynamic Research Lab at Ohio State, and the Nuclear Center at Battelle.

Conference proceedings will be published later this year.

The full meeting program follows:

Monday, July 20
THERMODYNAMIC PROPERTIES OF PROPELLANTS

9:00 a.m. — **East Ballroom, Ohio Union**

Chairman: Charles W. Beckett, National Bureau of Standards, Washington, D.C.

Vice-Chairman: Joseph Hilsenrath, National Bureau of Standards, Washington, D.C.

✦Thermal Functions of the Major Vapor Species in the B-O-H System at Elevated Temperatures, David White, Ohio State Univ., Columbus, Ohio; David E. Mann, National Bureau of Standards, Washington, D.C.; Patrick N. Walsh, and Armin Sommers, The Ohio State Univ.

✦Thermodynamic Properties of the Water—Boric Oxide and Water—Lithium Oxide Systems by Mass Spectrometric Methods, William A. Chupka, Joseph Berkowitz, and David J. Meschi, Argonne National Lab., Lemont, Ill.

✦Spectra and Thermodynamic Properties of Light Element Oxides and Hydroxides, Leo H. Spinar, Sterling P. Randall, Frank T. Greene, and John L. Margrave, Univ. of Wisconsin, Madison, Wis.

✦Detonation Velocity Study of the Diborane—Air System, Frederick Martin and Paul Kydd, General Electric Research Lab., Schenectady, N.Y., and William Browne, General Electric Flight Propulsion Lab., Cincinnati, Ohio.

HANDLING OF HIGH-ENERGY FUELS

9:00 a.m. — **Conference Theatre, Ohio Union**

Chairman: Lt. Col. John D. Seaberg, Air Research and Development Command, Washington, D.C.

Vice-Chairman: Marc Dunham, Wright Air Development Center, Wright-Patterson AFB, Ohio.

✦Large Scale Production, Storage, and Transportation of Liquid Hydrogen, P. C. Vander Arend, Air Products, Inc., Allentown, Pa.

✦Safety Aspects in Handling and Storage of Liquid Hydrogen, W. A. Sawyer, F. E. Maddocks, L. H. Cassutt, A. D. Little, Inc., Cambridge, Mass.

✦Experience with Handling Liquid Hydrogen in Engine Testing, C. D. Robin, Pratt and Whitney Aircraft, West Palm Beach, Fla.

✦Handling, Transfer, and Storage of High Energy Borane Rocket Fuels, Paul Knoll, Olin-Mathieson Chemical Corp., Niagara Falls, N. Y.

LUNCHEON

Noon — **East Ballroom, Ohio Union**

Toastmaster: Loren E. Bollinger, 1958 President, ARS Columbus Section.

Introduction: Harold A. Bolz, Dean, College of Engineering, Ohio State Univ., Columbus, Ohio.

Speaker: Gordon B. Carson, Vice-President—Business and Finance, Ohio State Univ., Columbus, Ohio.

THERMODYNAMIC PROPERTIES OF PROPELLANTS

2:00 p.m. — **East Ballroom, Ohio Union**

Chairman: Charles W. Beckett, National Bureau of Standards, Washington, D.C.

Vice-Chairman: Joseph Hilsenrath, National Bureau of Standards, Washington, D.C.

✦Quantum Mechanical Studies of the Properties of Diatomic Molecules of the Light Elements, Clemens J. Roothaan, Univ. of Chicago, Chicago, Ill.

✦Current Thermodynamic Research on Light Element Compounds at the National Bureau of Standards, Thomas B. Douglas, National Bureau of Standards, Washington, D.C.

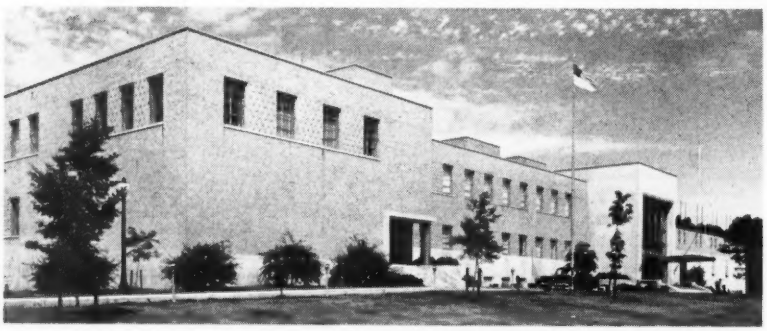
✦Some Aspects of Fluorine Flame Spectroscopy, David E. Mann, National Bureau of Standards, Washington, D.C.

✦Some Physical Properties and the Structure of Liquid Boron Trioxide, J. D. Mackenzie, General Electric Research Lab. Schenectady, N.Y.

HANDLING OF FLUORINE PART I

2:00 p.m. — **Conference Theatre, Ohio Union**

Chairman: Hans R. Neumark, General



Ohio Union building at Ohio State Univ., scene of the ARS Propellant Thermodynamics and Handling Conference July 20–22.

U. S. ARMY ANTI-MISSILE MISSILE

The man:

. . . a top missile scientist at White Sands, N. M., missile range where preliminary *Nike Zeus* tests take place. He is a key member of the highly specialized military-civilian team that is putting this agile anti-missile missile through its development stages.

When *Zeus* goes on active duty, it will follow Douglas *Nike Ajax* and *Hercules* missiles into service with the North American Air Defense Command. And it will be maintained by Army personnel assisted by Douglas field service men who have extensive experience in the *Nike* program.

The mission:

. . . anti-missile defense. *Zeus* will roar out from emplacements around cities and industrial and military areas to intercept approaching enemy ICBM's . . . or bombers.

CLASSIFIED

The missile:

. . . *Nike Zeus* is being developed by Douglas under a Western Electric-Bell Telephone program. System will include electronic detection gear to pick up enemy ICBM's at extreme range and then guide *Zeus* out to destroy them. Vital statistics. CLASSIFIED.

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Chemical Div., Allied Chemical Corp., Morristown, N.J.

Vice-Chairman: Edmund R. Jonash, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio.

✦The Transportation, Transfer, and Storage of Liquid Fluorine, J. M. Siegmund, General Chemical Div., Allied Chemical Corp., Morristown, N.J.

✦Materials of Construction for Handling Fluorine, F. W. Fink and E. L. White, Corrosion Research Div., Battelle Memorial Institute, Columbus, Ohio.

✦The Toxicity of Fluorine and Hydrogen Fluoride, E. J. Largent, Reynolds Metals Co., Richmond, Va.

✦Some Problems in Using Fluorine in Rocket Systems, Harold W. Schmidt and Edward A. Rothenberg, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio.

BANQUET

7:30 p.m. — **Grand Ballroom, Deshler-Hilton Hotel**

Toastmaster: Emerson W. Smith, President, Columbus Section ARS.

Introduction: Capt. Charles E. McCombs, U.S.N., Professor of Naval Science, Ohio State Univ. Columbus, Ohio.

Speaker: Rear Adm. John E. Clark, U.S.N., Deputy Director, Advanced Research Projects Agency, Washington, D.C.

TUESDAY, JULY 21

THERMODYNAMICS AND COMBUSTION PROCESSES

9:00 a.m. — **Room 331, Ohio Union**

Chairman: James A. Bierlein, Wright Air Development Center, Wright-Patterson AFB, Ohio.

Vice-Chairman: Marion L. Smith, Ohio State Univ., Columbus, Ohio.

✦Thermodynamics of the Steam Rocket—I, Ideal Performance, Denis J. Zigrang, The Martin Co., Denver, Colo.

✦Thermodynamics of the Steam Rocket—II, Effect of Condensation Shocks on Performance, Arthur Widawsky, North American Aviation, Inc., Downey, Calif. and Denis J. Zigrang, The Martin Co., Denver, Colo.

✦Propagation of Sound Waves Through Chemically Reacting Gas Mixtures, Sheng T. Chu and Rudolph Edse, The Ohio State Univ., Columbus, Ohio.

✦Propagation of Shock Waves Through Chemically Reacting Gas Mixtures, Rudolph Edse, The Ohio State University Columbus, Ohio.

HANDLING OF FLUORINE PART II

9:00 a.m. — **Conference Theatre, Ohio Union**

Chairman: Hans R. Neumark, General Chemical Div., Allied Chemical Corp., Morristown, N.J.

Vice-Chairman: Edmund R. Jonash, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio.

✦Fluorine Disposal, James Rollbuhler, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio.

✦Decontamination of Fluorine Spills, Part 1—Laboratory and Pilot Plant Studies, J. M. Siegmund, General Chemical Div., Allied Chemical Corp., Morristown, N.J.

✦Decontamination of Fluorine Spills, Part II—Large-Scale Spills of Liquid Fluorine, N. J. Vanderhyde and Lt. R. P. Rickey, Air Force Flight Test Center, Edwards Air Force Base, Calif.

ROCKET PERFORMANCE CALCULATION TECHNIQUES

9:00 a.m. — **East Ballroom, Ohio Union**

Chairman: David Altman, United Research Corp., Menlo Park, Calif.

Vice-Chairman: James J. Ward, Battelle Memorial Institute, Columbus, Ohio.

✦A General Computer Program for Calculation of Rocket-Engine Performance Parameters, P. A. Crisman, S. R. Goldwasser, and P. J. Petrozzi, Aerojet-General Corp., Sacramento, Calif.

✦The Rocketdyne N-Element Performance Program, Jack Silverman and Roger Wilkins, Rocketdyne Div., North American Aviation, Canoga Park, Calif.

✦Theoretical Calculations in Gaseous Detonation, Charles L. Eisen, Fairchild Engine and Airplane Corp., Deer Park, N.Y.

✦A General Method of Computing Rocket Performance for an IBM 650, Sanford Gordon, Frank Zeleznick and Vearl N. Huff, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio.

LUNCHEON

Noon — **East Ballroom, Ohio Union**

Toastmaster: Alexis W. Lemmon Jr., Conference Co-Chairman.

Introduction: John W. Clegg, Manager, Department of Chemical Engineering, Battelle Memorial Institute, Columbus, Ohio.

Speaker: Bertram D. Thomas, President, Battelle Memorial Institute, Columbus, Ohio.

COMBUSTION

2:00 p.m. — **Room 331, Ohio Union**

Chairman: George R. Gehrkens, North American Aviation, Inc., Columbus Div., Columbus, Ohio.

Vice-Chairman: Samuel Kaye, Convair Scientific Research Lab., San Diego, Calif.

✦Calculation of Detonation Parameters for Gaseous Mixtures, Bernard T. Wolfson and Robert G. Dunn, Aeronautical Research Lab., Wright Air Development Center, Wright-Patterson AFB, Ohio.

✦Effect of Initial Pressure and Temperature on the Detonation Induction Distances in Hydrogen-Oxygen and Acetylene-Oxygen-Nitrogen Mixtures, Loren E. Bollinger and Rudolph Edse, Department of Aeronautical Engineering, Ohio State Univ., Columbus, Ohio.

✦Problems Connected with the Afterburning of Rocket-Exhausts, H. G. Wolfhard, Reaction Motors Div., Thiokol Chemical Corp., Denville, N.J.

✦Handling of Exhaust Products from Ram-

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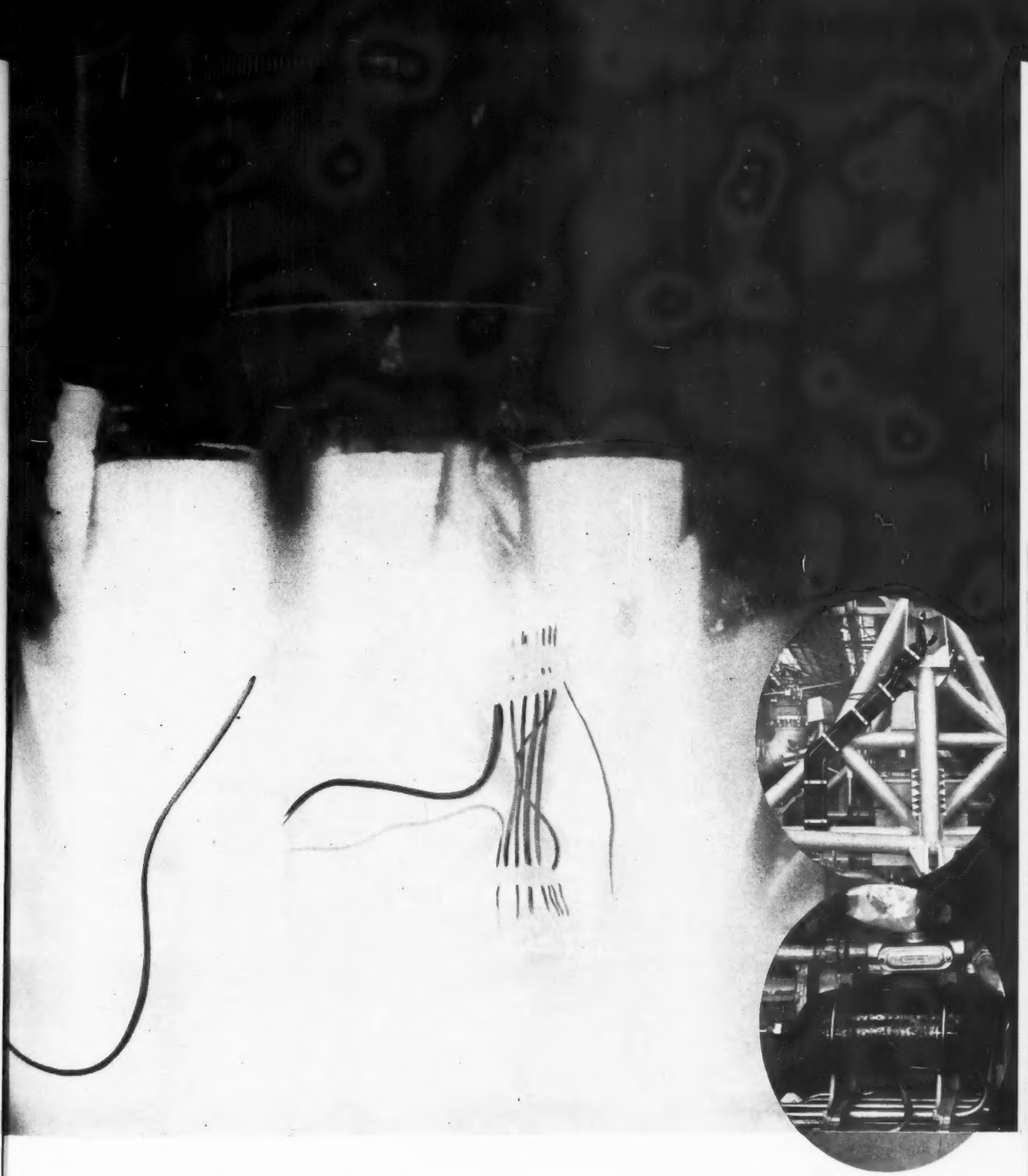

NEW ROCKET BLAST PROTECTION — by Swedlow

New ablative/insulative wrapping by Swedlow protects Atlas missile launcher tubes from direct rocket blast up to 5000°F. The materials and methods developed to meet this extreme demand hold great promise for many other applications requiring resistance to elevated temperatures.

To meet the rigid standards for this CONVAIR missile Swedlow has developed methods of:

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Write for technical bulletin "S" entitled "High Temperature Phenolic Laminates." Please refer to Dept. 18.

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jet Testing of Boron-Containing Fuels, Daniel W. Dembrow, Applied Physics Lab., The Johns Hopkins University, Silver Spring, Md.

PROPELLANT HANDLING

2:00 p.m. — **Conference Theatre, Ohio Union**

Chairman: Robert B. Filbert Jr., Battelle Memorial Institute, Columbus, Ohio.

Vice-Chairman: Winston L. Hole, The Ohio State Univ. Research Foundation, Columbus, Ohio.

✦Liquid Ozone—Effect of Low Ozone Concentrations on Combustion Efficiency and Propellant Handling, Riley O. Miller, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio.

✦Analysis of the Rapid Cooldown of a Liquid Oxygen Loading System, Martin M. Koshar and John Hoerning, The Martin Co., Denver, Colo.

✦A New Solution to the Missile Prelaunch Aerodynamic Heating Problem Through the Use of Storable Liquid Rocket Powerplants, Nathaniel Hughes, Reaction Motors Div., Thiokol Chemical Corp., Denville, N.J.

✦The Development of a Corrosion Inhibitor for Fuming Nitric Acids, Sam A. Long, William H. Bergdorg, and Edward J. Kinsley, Bell Aircraft Corp., Buffalo, N.Y.

PERFORMANCE ANALYSIS AND THERMODYNAMICS

2:00 p.m. — **East Ballroom, Ohio Union**

Chairman: Peter L. Nichols Jr., Poulter Labs. Stanford Research Institute, Menlo Park, Calif.

Vice-Chairman: Richard E. Bowman, Battelle Memorial Institute, Columbus, Ohio.

✦Effects on Rocket Performance Resulting from Chemical Reactions in Expansion Processes, Milton Farber and A. Lucile Cox, Aircraft Div., Hughes Tool Co., Culver City, Calif.

✦Comparison of Specific Impulse Measured Experimentally with Theoretical Values Calculated for Various Non-Ideal Conditions, Leonard Garden, Aerojet-General Corp., Sacramento, Calif.

✦The Analysis of Some Uncertainties in Performance Calculations, Walter H. Jones, Aeronutronic Systems, Inc., Glendale, Calif.

✦Thermodynamic Properties of Propellant Combustion Products, Robert Altman, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif.

1000 Attend "Best Ever" Telemetering Conference

"The best meeting ever held on telemetering." That about sums up the Tenth Annual National Telemetering Conference in Denver May 25–27, since this was the most frequently heard comment about the meeting from those in attendance.

Co-sponsored by ARS, AIEE, IAS, and ISA, with the meeting this year the responsibility of ARS, the conference attracted an attendance of more than 1000 people, anxious to hear some 50 technical papers delivered at 10 sessions; to sit in on two impressive panel discussions; to see and talk about the latest in telemetry equipment and components on display at the exhibit which was a feature of the meeting; and to witness the presentation of the first National Telemetering Conference Award.

They also had an opportunity to hear addresses by Cmdr. Robert F. Freitag (USN), Pacific Missile Range Planning Officer, and Joseph A. Boyd, director of the Willow Run Laboratories of the Univ. of Michigan, at the two conference luncheons, and the first public address by Maj. Gen. O. J. Ritland (USAF) since his appointment to succeed Lt. Gen. Bernard A. Schriever as commanding general of the AF Ballistic Missile Div., at the banquet. Field trips to the nearby Air Force Academy at Colorado Springs, Martin-Denver, and the National Bureau of Standards at Boulder constituted an added attraction.

With conference proceedings (containing almost all the papers presented) available before the meeting began, the technical sessions—devoted to system integrity, miniaturization, components, ground stations, data processing, biomedical telemetry, measurement and control, and RF components and techniques—were relatively informal, with authors presenting brief summaries of their papers, rather than attempting to read the full text. This method encouraged discussion, and lengthy question-and-answer periods and full-scale analyses of the subject were the rule, rather than the exception, at the meeting.

The two panel discussions were undoubtedly conference highlights. The first, devoted to the Past, Present, and Future of Space Investigation, in line with the meeting's "Investigation of Space" theme, and bringing together William H. Pickering of JPL, George Mueller of Space Technology Labs, John P. Hagen of NASA, F. J. Krieger of Rand Corp. (see page 43), and Col. John P. Stapp, chief of the AF Aero Medical Lab and ARS President, with conference chairman Max A. Lowy of Data Control Systems as moderator, was generally acknowledged to be one of the very finest ever devoted to the subject. The second panel, devoted to the Future of Telemetering, was chaired by W. J. Mayo Wells of the National Bureau of Standards, organizer of the first National Telemetering Conference 10 years ago, and presented with the first conference award—an Atmos clock—at the banquet. This panel was made up of eight experts who took part in a stimulating discussion of where telemetry was going and what the basic needs were in such fields as missiles, astronautics, underwater exploration, geological experiments, etc.

In his banquet address, Gen. Ritland discussed the AF ballistic missile program and the importance of telemetry to the program, while touching on the contributions being made by Thor and Atlas to the nation's space program. Cmdr. Freitag dealt with the nation's missile ranges, noting that,

ARS Paper Deadlines

Date	Meeting	Location	*Deadline
1959			
July 20–22	Propellant Thermodynamics & Handling Conference	Ohio State Univ.	Past
Aug. 24–26	Gas Dynamics Symposium	Northwestern Univ.	Past
Aug. 31–Sept. 5	10th IAF Congress	Westminster, London	Past
Nov. 16–20	14th Annual Meeting	Washington, D.C.	Aug. 17
1960			
Jan. 28–29	Solid Propellants Conference	Princeton Univ.	Nov. 16

* For reviewed and approved manuscripts in the New York office. Subtract 30 days for unsolicited papers that must go through the reviewing procedure and 60 days for abstracts submitted for consideration. Send all papers and abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

Space age research gets a new headquarters—One of the largest and best-equipped research facilities in the nation is the new 16-million-dollar Avco Research Center at Wilmington, Massachusetts. Here, research and development in space age technology is already being conducted in areas ranging from missile re-entry to satellite design. From work such as this—and equally important work at the nearby Avco Research Laboratory—will come further contributions to national security and the conquest of space.

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in the not-too-distance future, the Atlantic and Pacific missile ranges, as well as the proposed equatorial range, the White Sands range, and other ranges, will be combined into one global range. Dr. Boyd's address was concerned with the role of telemetry in combat surveillance and target acquisition.

The impressive conference program, as well as the special events which marked it, were due in no small measure to the conference committee, headed by National Chairman Max Lowy, Vice-Chairman Hugh Pruss of Telemetering Corp. of America, and Program Chairman Allan P. Gruer of Sandia Corp. Elliot Ring of Martin-Denver, president of the ARS Central Colorado Section, which acted as host section for the meeting, also is deserving of a hand for his part in setting up meeting arrangements.

—Irwin Hersey

Six More Companies Become ARS Members

Six more companies have become corporate members of the AMERICAN ROCKET SOCIETY. The companies, their areas of activity, and those named to represent them in Society activities are:

Astro-Electronic Products Div. of Radio Corporation of America, Princeton, N.J., engaged in complete satellite and space vehicle payload design, including supporting ground systems and subsystems. Representing the company in ARS are Barton Kreuzer, manager, marketing; Sidney Sternberg, chief engineer; E. A. Goldberg, manager, design engineering; Donald L. Gunter, manager, market development; and M. G. Staton, planning administrator.

Defense Systems Dept. of General Electric Co., Syracuse, N.Y., which will be represented by A. A. Ficket, special program section; G. L. Haller, vice-president, Defense Electronics Div.; R. C. Raymond, Technical Military Planning Operation; Gen. H. S. Hansell, J. K. Record, and R. L. Sheller, of the Defense Systems Dept.

Giannini Plasmadyne Corp., Santa Ana, Calif., engaged in research work on electric (plasma) and other advanced propulsion systems for space vehicles, and in high-temperature gas research and re-entry simulation. Designees are Ralph H. Goodwin, vice-president and treasurer; Adriano C. Ducati, vice-president, development engineering; Ralph W. Waniek, director of research, Magnetohydrodynamics Lab; Robert D. Webb, manager, Product Div.; and Delbert G. Van Ornum, manager, Space Physics Lab.

Space/Aeronautics Magazine, 205 East 42 St., New York 17, N.Y., publishers. Representing the company are William G. Maass, publisher; R. Hawthorne, editor; J. Holahan, electronics editor; V. DeBiasi, systems editor; and D. Ewald, sales manager.

Space Technology Laboratories, Inc., P.O. Box 95004, Los Angeles 45, Calif., engaged in systems engineering and technical direction of Air Force ballistic missile programs; research and development of space vehicle systems, including propulsion, airframe, nose cone, GSE; advanced guidance techniques; telecommunications systems, including microminiaturization; environmental testing; advanced airborne computers; fundamental physical research in the fields of magnetohydrodynamics, plasma physics, and superconductivity. Representing the company in ARS are Louis G. Dunn, president; Reuben F. Mettler, executive vice-president; William M. Duke, vice-president and director, R&D Div.; Milton U. Clauser, vice-president and director, Physical Research Lab; Allen F. Donovan, vice-president for Advanced Systems Planning.

On the calendar

1959	
July 20–22	**ARS Propellant Thermodynamics and Handling Conference, Ohio State Univ., Columbus, Ohio.**
July 24–26	AIEE Air Transportation Conference, in conjunction with 1959 Summer and Pacific General Meeting, Olympic Hotel, Seattle, Wash.
Aug. 9–12	ASME-AICE Heat Transfer Conference, Univ. of Connecticut, Storrs, Conn.
Aug. 18–21	1959 Western Electronic Show and Convention, San Francisco.
Aug. 24–26	**ARS Gas Dynamics Symposium, Dynamics of Conducting Fluids, Northwestern Univ., Evanston, Ill.**
Aug. 27–29	American Physical Society 1959 Summer Meeting in the West, Univ. of Hawaii, Honolulu.
Aug. 28–29	British Commonwealth Space Flight Symposium, Westminster, London.
Aug. 31-Sept. 2	4th Int'l Symposium on Free Radical Stabilization, sponsored by National Bureau of Standards, at Dunbarton College Auditorium, Washington, D. C.
Aug. 31–Sept. 5	**10th Annual International Astronautical Federation Congress, Westminster, London.**
Sept. 1–2	Physical Chemistry in Aerodynamic Spaceflight Conference, jointly sponsored by AFOSR and GE MSVD, at Univ. of Pennslyvania, Philadelphia.
Sept. 2–4	1959 Cryogenic Engineering Conference, Univ. of California, Berkeley, Calif.
Sept. 9–11	Midwestern Conference on Fluid and Solid Mechanics, Univ. of Texas, Austin.
Sept. 22–24	Industrial Nuclear Technology Conference, co-sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Sept. 28–Oct. 1	American Welding Society Fall Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.
Oct. 6–9	Int'l Symposium on High Temperature Technology, sponsored by Stanford Research Institute, at Asilomar, Calif.
Oct. 7–9	ASME-AIME Solid Fuels Conference, Cincinnati, Ohio.
Oct. 7–9	6th National Symposium on Vacuum Technology, American Vacuum Society, Sheraton Hotel, Philadelphia.
Oct. 12–14	National Electronics Conference, co-sponsored by Illinois Inst. of Tech., at Hotel Sherman, Chicago.
Oct. 26–28	IRE Professional Group East Coast Conference on Aeronautical and Navigational Electronics, Lord Baltimore Hotel, Baltimore, Md.
Oct. 26–30	1959 National Conference of the Society of Photographic Scientists and Engineers, Edgewater Beach Hotel, Chicago.
Oct. 28–29	6th Annual Computer Applications Symposium, sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Nov. 16–20	**ARS 14th Annual Meeting and Astronautical Exposition, Washington, D.C.**
Nov. 16–20	5th Int'l Automation Exposition and Congress, N.Y. Trade Show Bldg., New York, N.Y.
1960	
Jan. 28–29	**ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.**
Aug. 31–Sept. 7	10th Int'l Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.

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ARS and ASME Presidents Issue Statement of Affiliation

Formal announcement of the nature of the affiliation that exists between the American Society of Mechanical Engineers and ARS was made recently by ASME President Glenn B. Warren and ARS President John P. Stapp.

The two societies have had formal agreements on affiliation since the mid-forties. This is the first statement, however, to be printed in the respective Societies' publications. Main advantages of the affiliation are that ARS members can purchase ASME publications at ASME member rates, and vice versa. Also, each can join the other Society without payment of initiation fee (although ARS does not have an initiation fee). As in the past, members of the two Societies can attend each other's meetings at member registration fee.

The complete statement, including costs of publications, is below:

The affiliation existing between The American Society of Mechanical Engineers and the American Rocket Society offers the membership of both Societies a broad spectrum of scientific and engineering activities.

Mutual cooperation is effected through an ASME-ARS Joint Committee and through representation of each Society on the appropriate governing body of the other.

The advantages to the membership of each Society of this affiliation include the following:

(a) Joint meetings at which the complete program of each Society is open to the membership of the other Society.

(b) Coordination of technical program planning through cooperation of professional divisions of the two Societies so that the interests of the members of both Societies may be better served.

(c) A member of one of the two Societies may become a member of the other without payment of initiation or entrance fees in the second Society provided he can qualify for membership in the second Society.

(d) Members of each Society are extended the privilege of purchasing publications of the other Society at the members' rate. The following tabulation shows the existing rates:

ARS Publications	Nonmembers	Members
ARS Journal	$12.50	$ 6.25
Astronautics	9.00	4.50
Technical Papers	.50	.25
ASME Publications		
Applied Mechanics Reviews	25.00	10.00
PMM-Journal of Applied Mathematics and Mechanics	35.00	28.00
Mechanical Engineering	7.00	5.60
ASME Transactions (Bound)		
(1958 Volume and earlier)	30.00	15.00
(Quarterly, beginning January 1959).		
Journal of Heat Transfer	10.00	5.00
Journal of Basic Engineering	10.00	5.00
Journal of Engineering for Power	10.00	5.00
Journal of Engineering for Industry	10.00	5.00
Journal of Applied Mechanics	10.00	5.00
Individual technical papers	.80	.40
Books, Codes, and Standards	Various	20% discount

Glenn B. Warren, President
American Society of Mechanical Engineers

John P. Stapp, President
American Rocket Society

SECTIONS

Alabama: Section members were special guests at ABMA's third annual open house in February. Among other things, the members viewed a 150-sec static test of the Jupiter missile; toured the test area; and saw the million-pound thrust test stand used to test Jupiter, the test stand used to simulate flow problems and changes in structural loading, and the blockhouse where the multitude of information from a Jupiter test is continuously recorded.

—David R. Mills

Chicago: The April meeting featured a tour of the Burnham Park Nike Site and the election of officers. The tour, conducted by Lt. Ellis, included a briefing and demonstrations of the radar, launching, and assembly facilities.

Elected to take office in May were C. Charles Miesse of Armour Research, president; Joseph Elward of Atlas Powder, vice-president; Allen Fuhs of Northwestern Univ. Technological Institute, secretary; and Ben Harrison of Armour Research, treasurer.

Columbus: The final meeting of the current spring season was a ladies-night dinner held in May at Ann-Ton's Restaurant in Worthington, Ohio. James Harp, vice-president and program chairman, introduced guest speaker **Richard J. Anderson,** assistant to the director of Battelle Memorial Institute, whose topic was "Journey into Ignorance."

This was a description and commentary on the purposes, methods, and results of investigations during the International Geophysical Year, in which were reviewed study of the earth's interior by recording waves from earthquakes and nuclear-bomb detonations; the need in military and commercial navigation for accurate location of the magnetic poles and the land areas of the earth's surface; mapping of ocean-floor topography and ocean currents; relation of the atmosphere to the earth and the necessity for more information to assist in weather forecasting; and various space vehicles launched by the U.S. and the Soviet Union.

He reminded the audience that the original purpose of the satellite program was to put up an instrumented vehicle capable of gathering data aloft for a longer period than is possible with a sounding rocket. He stated that this scientific origin of the satellite program has now been largely obscured by the national prestige associated with a successful launching. Similarly, he felt that in the public viewpoint the prestige factor has become paramount in plans for future shots to the moon and Venus.

This proved an extremely effective and very humorous talk, enjoyable for all those attending.

—Tobenette Holtz

Dayton: Members and guests at the annual dinner meeting, held in May at the Dayton Biltmore Hotel, heard **Lovell Lawrence Jr.,** past Detroit section and national ARS president, predict that there would be a man (nationality unpredicted) on the moon in the next five years, and, admittedly looking far into the future, forecast a passenger space vehicle that will resemble a huge discus. This shape would permit rotation of the spacecraft to give "artificial gravity" on lengthy travel in outer space. The de-

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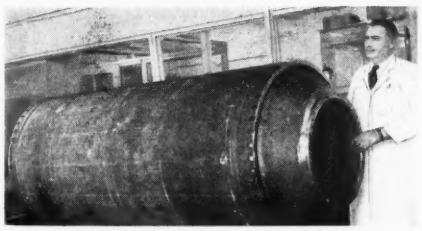

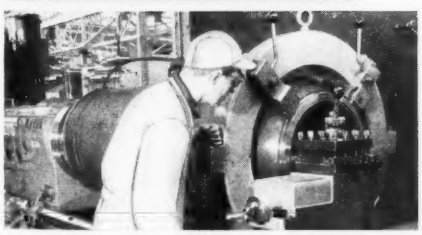

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The Ingersoll Kalamazoo Division has been producing missile metal parts since 1951 when the first Snark booster cases were made. Today, nearly half the Nike Hercules boosters and sustainers have been made with Ingersoll Kalamazoo Division production skills.

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A capable staff of engineers is available at the Ingersoll Kalamazoo Division who are experienced in the DESIGN, FABRICATION AND ASSEMBLY of major missile hardware parts. These engineers are ready to tackle your problems.

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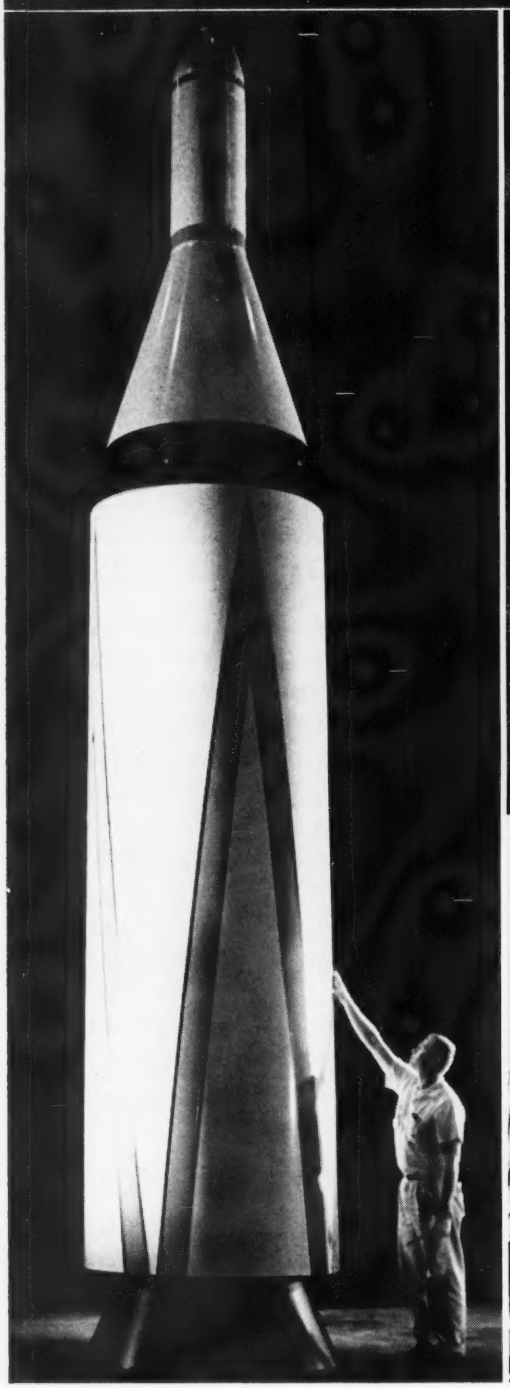
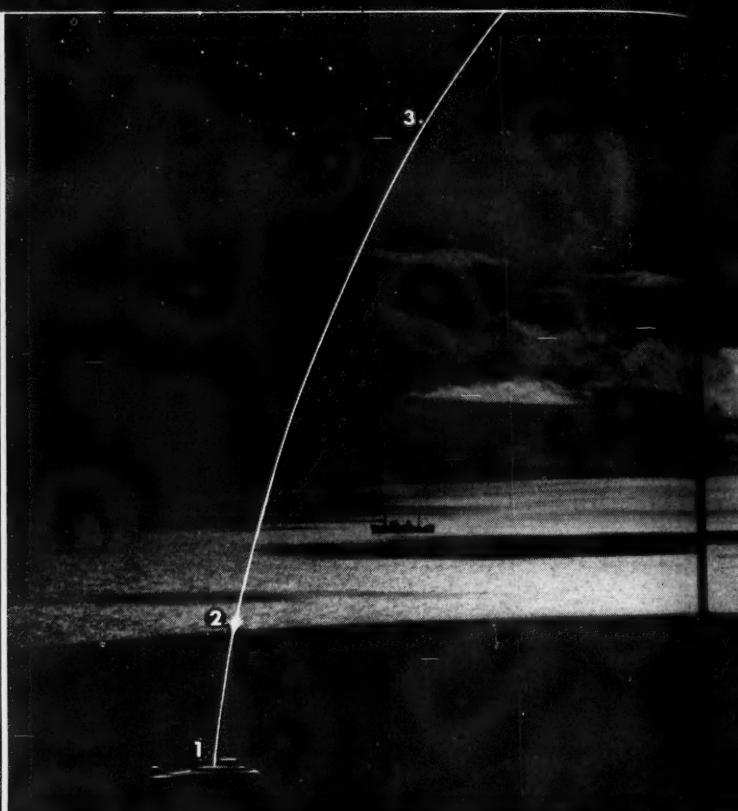
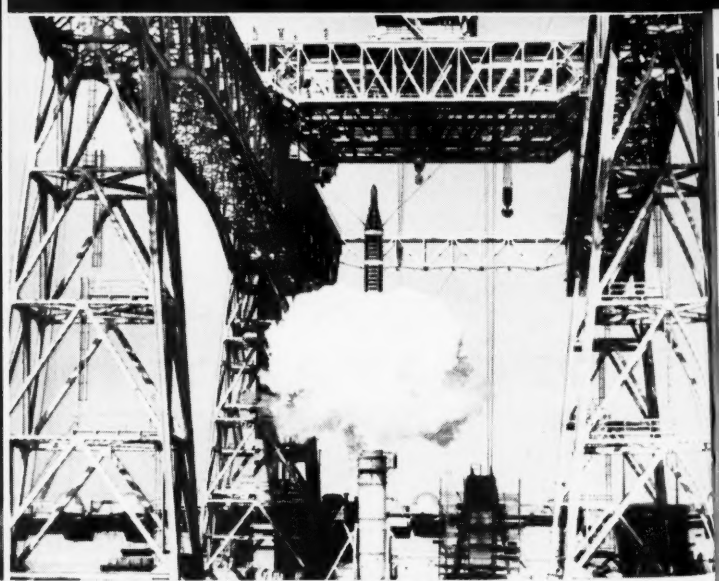






Left: *"Operation Sky-Catch" tests,* conducted jointly by U. S. Navy, Westinghouse and Lockheed, reveal effects of launch stresses. To prevent damage to POLARIS test missile components, huge overhead assembly catches it in mid-air.

Far left: *Carrying awesome destructive power,* Navy's POLARIS is markedly smaller than other U. S. ballistic missiles of same range. To enable one submarine to carry many missiles, Lockheed scientists achieved miniaturization breakthroughs on all major systems of POLARIS.

Above: *Propulsion system firings* light up night sky at Lockheed Missiles and Space Division's 4000-acre test base in the Santa Cruz mountains, Calif. A nearby vertical test stand permits simulated flights of complete POLARIS missiles, to test their propulsion and guidance systems.

Left: *Nuclear powered U. S. Navy sub* (1) launches solid-propellant POLARIS missile which erupts from ocean depths (2)—then rockets its way on a ballistic missile trajectory high above the earth's atmosphere (3) into outer space. Re-entering the atmosphere (4) the re-entry body of the POLARIS plunges earthward to destroy its target (5).

Launching an IRBM from submerged submarines involves technological developments that are unique in ballistic missile history.

As POLARIS Missile System manager and prime contractor, Lockheed's Missiles and Space Division is responsible for coordinating all phases of its design, development, and production.

The POLARIS, a solid-propellant missile, will be operational in 1960—ahead of schedule. The operational missiles will be delivered to U. S. Navy submarines in Lockheed ready-service transporters under controlled humidity and temperature conditions. And Lockheed's ACRE—Automatic Checkout and Readiness Equipment—will maintain the constant ready-to-fire capability of POLARIS missiles, right up to the moment of launch.

With an ultimate range of 1500 nautical miles, the POLARIS will become one of the most formidable deterrent weapons ever devised. For any significant military target on earth will be within range of its nuclear warheads.

LOCKHEED

JET TRANSPORTS • JET FIGHTERS • JET TRAINERS • COMMERCIAL & MILITARY PROP-JET TRANSPORTS • ROCKETRY
BALLISTIC MISSILE RESEARCH & DEVELOPMENT • WEAPON SYSTEM MANAGEMENT • ANTI-SUBMARINE PATROL AIRCRAFT
NUCLEAR-POWERED FLIGHT • ADVANCED ELECTRONICS • AIRBORNE EARLY-WARNING AIRCRAFT • AIRPORT MANAGEMENT
NUCLEAR REACTOR DESIGN & DEVELOPMENT • GROUND SUPPORT EQUIPMENT • WORLD-WIDE AIRCRAFT MAINTENANCE

Snapped at the Controllable Satellites Conference

John Harvell, of Arthur D. Little, Inc., president of the ARS New England Section, pays close attention as Rep. Overton Brooks (D., La.), chairman of the House Committee on Science and Astronautics, delivers address at banquet.

ARS National Vice-President Howard Seifert, Space Technology Labs (left), and Kurt Stehling of NASA (right) query Rep. Brooks about plans to launch mice in Discoverer shot.

Rep. Brooks discusses ARS Goddard Memorial with Mrs. Robert H. Goddard and Fred Durant of Avco, chairman of the ARS Goddard Memorial Committee.

sign would also assist in keeping the vehicle temperature at a bearable level by turning its thin edge toward the sun. Simple rotation of the body of the vehicle would control the surface exposed to the sun's radiation.

In addition, new section officers were installed by **William J. Cushing,** the first president and one of the founders of the Dayton section. He commented with pleasure on the rapid growth of the section in its first year of operation—from only a few to over 200 active members since spring of 1958.

The new officers are Capt. Roderick W. Clarke of ARDC, Wright-Patterson AFB, president; A. G. Liefke of Cook Electric, vice-president; Forrest S. Forbes of WADC's propulsion laboratory, treasurer; and Mrs. William J. Cushing, secretary.

ARS National President John Paul Stapp was the guest of honor at this meeting.

—**Don Bolton**

Fort Wayne: Section vice-president **A. B. Showalter** spoke on aspects of space navigation at the February meeting, describing basic principles of orbital mechanics and some of the better known navigational techniques and methods of instrumentation.

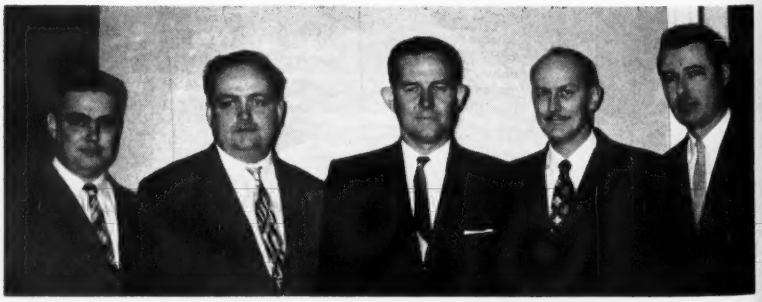
Section president **F. H. Brady** spoke at the March meeting, reviewing Rand Corporation's "Space Handbook." A lively discussion on the feasibility of placing radar beacons at the stable libration points of the earth-moon system dominated the question period.

Some 40 members and guests attended the section's fourth anniversary banquet in April. Guest **H. L. Karsch** of GM's Allison Div. spoke on "The Farside Rocket Research Program," of which he was project manager when with Aeronutronic Systems Inc. During the discussion period, he related some of his unique experiences during and after World War II with the German missile program and described how very advanced it was in many respects.

Maryland: The April dinner meeting, which was held at the Officer's Club of Aberdeen Proving Grounds, featured a talk by **Maj. Gen. Holger N. Toftoy** on Project Paperclip, the program which brought many of Germany's V-2 rocket engineers to this country. In view of the historical consequences of this action, Gen. Toftoy's recollections of the program and the selection of what engineers were to come proved very interesting. Gen. Toftoy did much to influence the adoption of rocket weapons by the Army, and it was under his direction that the Nike and Corporal missiles were developed.

North Texas: A good turnout of about 200 members and guests for the April dinner meeting had the pleasure of hearing ARS President **John Paul Stapp** discuss "Rocket Age Man." Col. Stapp pointed out many of the problems that must be solved before man can be projected into space and possible solutions to some of them. His talk included a movie showing the reaction of experimenters to high-g and weightless states. The meeting

Fourth Anniversary for Fort Wayne



H. L. Karsch (center) of GM Allison Div. was guest speaker at the Fort Wayne section's fourth anniversary dinner in April. Standing with him, from left, are D. K. Roberson, program chairman; F. H. Brady, section president; A. B. Showalter, vice-president; and M. L. Storlee, secretary.

ROCKET ENGINES

NEW tungsten linings for rocket nozzles...

MELTING POINT: 6170°F.

Tungsten-lined lightweight nozzles for solid propellant engines are now being fabricated by General Electric. With a lining melting point of 6170°F, these are among the highest temperature lightweight fixed and flexible nozzles in use in the missile industry, enduring high rocket propellant temperatures and pressures with no measurable erosion.

These nozzles are produced by an arc-spraying process pioneered by General Electric. Tungsten is vaporized in an arc and deposited on a mandrel. For some applications, the liner is molded in lightweight plastic, and the mandrel leached out.

Arc-sprayed nozzles have been hot-fired with the new high temperature propellants at several locations.

G.E.'s capabilities in metallurgy and manufacturing are combined with equally advanced capabilities in engineering, research and development. Integrated advanced rocket engine capabilities at General Electric can meet your needs for high performance solid propellant engine cases, nozzles and liquid engine components using cryogenic and storeable propellants.

Progress Is Our Most Important Product

GENERAL ELECTRIC

The Flight Propulsion Laboratory Department's Rocket Engine Section is the nucleus of General Electric progress in rocket engines and their components. It is well-equipped; and it uses Company-wide capabilities and experience to speed advances. If you would like more information about the section's products and capabilities in solid or liquid propulsion systems, please mail this coupon. Rocket Engine Section, General Electric Co., Cincinnati 15, Ohio.

Section K182-2
Rocket Engine Section
Flight Propulsion Laboratory Department
General Electric Company
Cincinnati 15, Ohio

Please send me additional information about General Electric solid propellant cases and nozzles (GED-3763). ☐

I would like to discuss G-E rocket engine products with a sales representative. ☐

Name.....
Title.....
Company.....
Address.....
City..... **State**.....

Some 200 members and guests (left) attending the April dinner meeting of the North Texas section heard ARS President John P. Stapp (center), who went western for the occasion, talk on "Rocket Age Man," and saw the section's new banner unveiled (right). At the left in this last photo is Mrs. George P. Koshiol, member's wife who made the banner, and standing next to her, John Kerr, section president.

Banner Day at North Texas

also featured the unveiling of the section's new banner, which was made by Mrs. George P. Koshiol.

—W. H. Bender

Sacramento: Some 80 members and guests attending the April meeting, held at the Town and Country Village Buffalo Room, heard guest **Lt. Col. Walter Schlie** of the USAF 292 Strategic Missile Squadron speak on "The Western Missile Range—Vandenberg Air Force Base, Its Mission, Present and Future." The base was activated as an Air Force facility in January 1957. A Titan launching complex is under construction there, and facilities are in operation in support of Thor. The assigned mission of Vandenberg entails bringing about an operational capability with ballistic missiles as soon as possible, and training IRBM-ICBM units to meet programmed requirements. The present emphasis is in training English RAF personnel in operation and maintenance of Thor. The Pacific Missile Range operates in support of the Vandenberg AFB. The U.S. Navy is responsible for the range and operates the telemetering and tracking equipment to locate test-missile impact points.

—Ira Nagin

Southern California: At the April meeting, held at the IAS Building in Los Angeles, **W. R. Kirchner,** associate manager for research and development at Aerojet-General's Solid Rocket Plant, presented a classified paper entitled "Development of the Propulsion System for the Polaris" and illustrated his talk with slides and a film. Members appreciated having the opportunity of so learning about the problems of developing large solid-propellant powerplants, and how these problems were overcome for the Polaris system.

—Eric Burgess

Southern Ohio: Early in April, this section and the local section of ASME joined in a mutual-interest meeting, which heard these speakers and subjects: **Herbert Friedman** of NRL, the keynote speaker, on "Interplanetary Space"; **Delbert E. Robison** of GE's Rocket Systems group, on "Rocket Systems"; **T. J. Keating** of WADC's Rocket Propulsion Div., on "Influence of Spaceflight on Rocket Propulsion System Design"; and **G. W. Boyd** of Emery Industries' Chemical Div., on "Last Year's Nests." This unusually fine program was preceded by a dinner and social hour.

The May dinner meeting was held jointly with the local section of ASME and the Institute of Environmental Engineers. Featured speaker of the evening was **Frederick R. Riddell** of Avco Research Laboratory, who discussed "Latest Developments in Re-Entry Research." Dr. Riddell has studied hypersonics and re-entry at Avco since 1955.

The following new officers were also elected at this meeting: Louis Michelson, president; Delbert E. Robison, vice-president; Mary C. Pope, secretary; and Bernard A. Free, treasurer—all of GE's Flight Propulsion Laboratory Dept.

University Park: In May, members met with the local section of ASME in the electrical engineering building of the Univ. of Pennsylvania to hear **John Bohuslaw,** design engineer with GE's

Niagara Frontier Display Hit of the Show

In 1958, the Niagara Frontier section, at the suggestion of its corresponding secretary, Bob Roach, prepared models of U.S. space vehicles and missiles and displayed them, as shown here, in the Industrial, Engineering, and Science Fair sponsored by the Technical Societies Council in Niagara Falls.

In 1959, the section prepared the other booth pictured, which features models, actual rocket hardware, illustrations of rocket fundamentals and things to come, and Bell Aircraft's "do-it-yourself" rocket test panel. The booth was featured on a CBS-TV newsreel as the hit of the show, which in toto was a great success, and a good example of community education.

Left, display of models prepared by the Niagara Frontier section for the Niagara Falls Industrial, Engineering, and Science Fair in 1958; and, right, the booth with Bell Aircraft "do-it-yourself" rocket test stand, models, hardware, and illustrations cited as hit of the show in 1959.

COUNT DOWN

for the conquest of space

"MISSION ACCOMPLISHED: DEPARTING LUNA 2205 ZEBRA"

This message, flashed across a quarter-million miles to Washington, D.C., will be awaited anxiously by millions.

But even then our first expedition to the moon will still face its most crucial test—the journey home to earth.

The success of that trip will depend in large part on rocket propellants—fuels and oxidizers that will have been stored for days in the tanks of the expeditionary vehicle and yet will respond instantly when needed.

Storable liquid propellants is one of the fields in which Rocketdyne has anticipated the future. For more than ten years, its propellant chemists have been studying, engineering, and testing combinations of storable fuels and oxidizers for greater storability and higher energy.

Storability PLUS high energy

Rocketdyne has tested these combinations in all production and experimental engines. The results prove that today's storable fuels and oxidizers have these important capabilities:

(1) High performance, even after months or years of storage; (2) Stability over a wide temperature range, permitting storage in missile tanks without rigid environmental controls; (3) Dependable performance, predictable even at extremes of heat and cold; (4) Instant readiness for firing at any time during the storage period; (5) Energy yields equal to or higher than those of conventional propellant combinations.

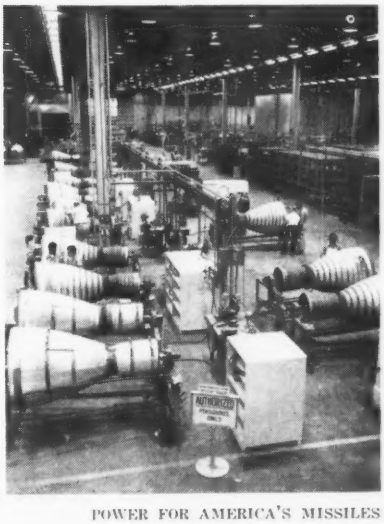
Second-generation missiles

The tests also prove that engines developed for conventional propellants can be converted to storable combinations rapidly and inexpensively—a significant consideration in the development of second and third generation strategic, tactical, and air defense missiles.

Significant, too, is the *potential* performance of storable combinations. Research points to energy yields as high as 400 seconds of altitude specific impulse—performance 20 percent higher than that of today's combinations. These high-energy yields will offer new capabilities and greater flexibility for America's scientific and military programs.

Stepping stones to Space

Rocketdyne has designed and built much of today's operating hardware in the high-thrust rocket field. Engines by Rocketdyne power most of the military and scientific projects sponsored by Air Force, Army, and NASA. This experience now becomes the point-of-departure for tomorrow's journeys into the unknown.



POWER FOR AMERICA'S MISSILES

Thrust chamber production line for Thor and Jupiter at Rocketdyne's Neosho, Mo., facility moves smoothly.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

Rockets Their Business

New Southern Ohio section officers, all of GE's Flight Propulsion Laboratory Dept., talk over the future: From left, Bernard Free, treasurer; Delbert Robison, vice-president; Mary Pope, secretary; and Louis Michelson, manager of FPL's rocket engine section, president.

Missile and Space Vehicle Dept., talk on "Travel Tips for Space Astronauts" and present a sound and color movie on the subject. Earlier in the year, the chapter elected the following officers: James D. Decker, president; Robert D. Moyer, vice-president; Jack M. Brame, secretary; and John A. Fox, treasurer.

Valley Forge: The April meeting featured a talk by **William Doyle,** director of Temple Univ.'s high-temperature test area, on "High-Temperature Propulsion Research." At the May meeting, guest **Richard H. Davis** of Wyle Associates spoke on "Component Testing for Ballistic Missiles and Space Vehicles."

STUDENT CHAPTERS

Univ. of Hartford: At a chapter meeting April 4, attended by some 40 students and four members of the faculty, **Carl W. Lemmerman,** president of the Connecticut Valley section, presented the chapter its ARS certificate of membership, and talked on the history of ARS. He also discussed the curriculum that would be necessary for the 3rd and 4th university semesters and necessary advanced training to secure an aeronautical space engineering degree.

—John Pethigal

Univ. of Oklahoma: The May meeting saw the following new officers elected: Elton Thompson, president; Robert Melton, vice-president; John Totten, secretary; and Florence Jones, treasurer. Then, after viewing a movie on satellites, the new and old members gathered to get better acquainted and to enjoy some refreshments.

—John K. Totten

TECHNICAL COMMITTEES

Education: Paul E. Sandorff, professor of the Dept. of Aeronautical Engineering at MIT has been appointed chairman of the Education Committee. Named by Prof. Sandorff to serve on the committee are: Ali B. Cambel, Northwestern Univ.; V. T. Cerf, Rocketdyne Div., North American Aviation; Maj. V. S. Haneman Jr., Air Force Institute of Technology, Wright-Patterson AFB; Samuel Herrick, Univ. of California; Capt. Grayson Merrill, Fairchild Astrionics Div.; Irving Michelson, Pennsylvania State Univ.; J. K. Noble Jr., Noble and Noble, Publishers, N.Y.C.; R. K. Sherburne, New Mexico College of Agriculture and Mechanical Arts; S. F. Singer, Univ. of Maryland; Kurt Stehling, NASA Vanguard Div.; T. Paul Torda, Polytechnic Institute of Brooklyn; and F. L. van der Wal, Space Technology Labs.

Sandorff

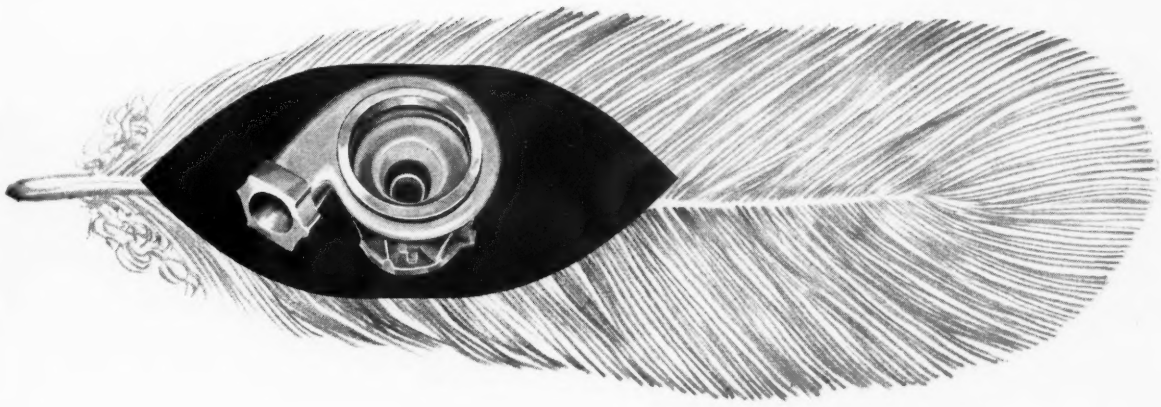
Propellants and Combustion: Chairman John L. Sloop has announced the following appointments to the Propellants and Combustion Committee: Ray E. Bolz, Case Institute of Technology; Ali B. Cambel, Northwestern Univ.; Benson E. Gammon, NASA; Jerry Grey, Princeton Univ.; Robert A. Gross, Fairchild Engine & Airplane Corp.; Arthur A. Kovitz, Northwestern Univ.; Alexis Lemmon Jr., Battelle Institute; Charles Marsel, NYU; Peter Nichols Jr., CalTech; A. K. Oppenheim, Univ. of California; Thomas F. Reinhardt, Bell Aircraft; and R. J. Thompson, Rocketdyne.

Sloop

Structures and Materials: Committee Chairman George Gerard, assistant director of research, New York Univ. College of Engineering, has announced the makeup of the Structures and Materials committee. Members are: Frederick L. Bagby, Battelle Memorial Institute; R. L. Bisplinghoff, MIT; Wilfred H. Dukes, Bell Aircraft; George A. Hoffman, Rand; Alan V. Levy, Marquardt Aircraft; Nathan Promisel, Navy Dept. Chief Metallurgist; E. A. Simkovich, Republic Aviation; Wolfgang H. Steurer, Convair; and Max L. Williams, CalTech.

Gerard

new weight saving material for missiles and high performance jet aircraft



NEW HIGH-STRENGTH . . . HIGH-PURITY ALUMINUM CASTING ALLOY

If you've been pushing A-356 to the limit of its physicals to scrape off every possible ounce of excess weight . . . then new alloy MA-356 was made to order for you. With a few minor changes in chemical composition, Rolle has produced what is essentially a new casting material. Highly responsive to heat treatment, it permits higher tensile strength, higher yield strength, and greater elongation. Rolle is pouring MA-356 now . . . in castings that consistently exceed the physical requirements of MIL-C-21180A. Check, for example, the typical sand cast range of properties MA-356 permits in the T-6 condition against what you can expect from conventional A-356 at left:

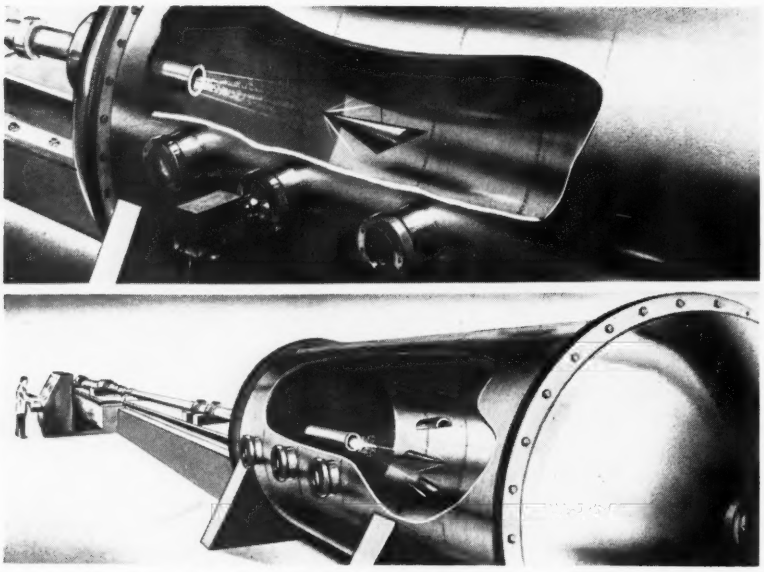
ALLOY (T-6)	U.T.S. (psi)	Y.S. (psi)	E (%)
A-356	40,000	30,000	3
MA-356			
minimum	40,000	30,000	5
maximum	50,000	40,000	2

One of the advantages of MA-356 is that any desired physical within the typical range can be emphasized through careful control of heat treatment of the casting. Even more exciting are the extremely high physicals that have been achieved with MA-356 in favorable casting configurations. Test castings have actually exceeded a tensile strength of 54,000 psi and yield strength of 44,000 psi with 2% elongation.

But no two castings are alike. It's impossible to predict the benefits MA-356 will confer on your sand and permanent mold castings without prints and specs. If you'd like more information on this new alloy, write for Technical Data Bulletin 1001. And when you do, why not ask for your copy of our 58-page light metals casting handbook . . . an engineering guide to aluminum and magnesium sand and permanent mold castings. Rolle Manufacturing Company, 319 Cannon Avenue, Lansdale, Pennsylvania, or call ULysses 5-1174.

ROLLE

Convair Hypersonic Gun Facility



Top, stationary model in hypervelocity stream; bottom, sabot-launched free-flight glider model test.

Convair has already begun construction of a $500,000 hypersonic gun facility at its San Diego Inter-Division R&D Center for studying missile flight and re-entry problems. The gun will either drive a model vehicle through a 100-ft long, 3-in. diam barrel into a controlled-atmosphere test chamber at a muzzle velocity of up to 20,000 fps, or shoot high-velocity, high-pressure gas past a stationary model. Driving gas will be a mixture of helium hydrogen and oxygen.

Soviet Astronautics

(CONTINUED FROM PAGE 43)

Nauk SSSR (Herald of the U.S.S.R. Academy of Sciences). In the article, Prof. Petrovich has outlined portions of this plan, noting that rocket technology aimed at the study and mastery of the cosmos is being developed in three phases, all of which are proceeding simultaneously.

First Phase

The first phase involves the creation of a series of artificial earth satellites varying in tonnage and purpose. The primary object is to establish in polar orbits a group of stabilized, so-called observer-satellites equipped with optical and television instruments that will put the entire earth under constant surveillance. This phase of the program also includes the recovery of satellites or their essential parts, with and without the use of aerodynamic surfaces. Recovery techniques are being perfected that will at first permit instrument containers to be retrieved, then animals, and finally human passengers. As techniques improve and methods become more reliable, the satellites will become larger and their mean altitude above the earth will increase from a few hundred kilometers for the first surveillance satellites to tens of thousands of kilometers for intermediate space stations, the latter eventually being used to service interplanetary vehicles.

The second phase in the study and conquest of space is linked with the earth's natural satellite—the moon. The initial step in this phase of the program was accomplished when the Soviet interplanetary rocket Mechta passed by the moon at a distance of less than 5000 km on its way into orbit around the sun. Subsequent steps will involve: (1) Circumflight of the moon with photography of its far side and transmission of the image to the earth as the rocket heads back toward the earth; (2) creation of artificial satellites of the moon which maintain constant communication with the earth; (3) deposition on the moon of heavy instrument packages containing radio, television, and telemetering equipment for the communication and transmission of scientific findings to the earth (for this step, the rocket must have a characteristic velocity of 14.5 km/sec, that is, 11.2 km/sec to escape from the earth, 3 km/sec to land on the moon, and a small increment for navigational corrections); (4) circumflight of the moon by a manned rocket with subsequent return to the earth; and (5) deposition on the moon of a manned rocket capable of taking off from the moon and returning to the earth (for this, the vehicle must have a characteristic velocity of slightly more than 17 km/sec).

This last step can also be achieved by means of less powerful rockets if stores and propellant supplies are deposited on the moon in advance to service and refuel the manned rocket for its return trip to the earth. As a precautionary measure, and at the same time to enhance the chances of a successful expedition, Soviet scientists consider it expedient to dispatch two "lunar" rockets simultaneously. The crews could be of mutual assistance to each other in exploring the moon and in preparing for the return trip; and, in case of emergency, could return to earth in one rocket.

The third phase of the program concerns the investigation of the planets of our solar system by means of (1) automatic reconnaissance rockets that will probe both the inner and the outer planets, and (2) a series of artificial satellites of the sun, of which Mechta is the prototype, that will move in prescribed orbits and continuously transmit information to earth. These probes and solar satellites are a necessary prerequisite for the further penetration of the cosmos.

Petrovich lists the following requirements as being necessary to achieve full development of the program: (1) Creation of larger and more effective rockets powered by engines of higher thrust; (2) improved rocket stabilization and control systems, as well as improved ground-launching facilities; (3) perfection of high-resolution multichannel telemetering equipment to transmit signals to earth over distances measured in millions of kilometers; and (4) broad development of space medicine, since the time is rapidly approaching when this branch of science will be called on to make specific recommendations.

Enjoying the privileges of top priority in the field of space technology, Soviet scientists, engineers, and technicians are laboring feverishly to fulfill Tsiolkovskii's dictum: "Mankind will not stay on earth forever, but, in the pursuit of light and space, will at first timidly penetrate beyond the limits of the atmosphere and then will conquer all the space around the sun."

COMPLETING THE PICTURE . . .

Nuclear Systems Economical, Portable Radiography Machines

MODEL 52 MULTITRON

At Convair, San Diego, steel parts for air or space craft must be absolutely flawless to take their designed loads. Quick, positive inspections of these parts are made by a Nuclear Systems Model 52 Multitron with a cobalt 60 source. The unit can be wheeled about at will . . . wherever radiographic inspection is needed.

Like Convair, companies all over the country are making sure of quality, saving time and money by inspecting with radiography machines from Nuclear Systems.

If you have an inspection problem, Nuclear Systems has a safe, portable, economical radiography machine to suit your needs. For full information, contact Dept. A-7 at one of our sales offices. Also . . . inquire about Nuclear Systems' regularly scheduled three-day Radiation Health Physics Course —an approved AEC licensing aid.

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In print

Dictionary of Guided Missiles and Space Flight, edited by Grayson Merrill, D. Van Nostrand Co., Princeton, N. J., 1959, 688 pp., illus. $17.50.

This latest volume in Van Nostrand's major series on guided missile design is a long-awaited one, and one which belongs on the desk or bookshelf of every rocket and missile engineer, for it fills a need which has existed in this field for many years.

Editor Grayson Merrill and his contributing editors—C. W. Besserer, Krafft Ehricke, and Maj. Ballard B. Small—have taken on a Herculean task, and pulled it off very neatly indeed. In 688 fact-filled pages, and hundreds of accompanying illustrations, charts, and diagrams, they have managed to cover literally thousands of commonly used terms, and thus gone a long way toward establishing a common language for the field of rocketry, guided missiles, and astronautics.

These terms are not only defined, accurately and concisely, but also are explained in considerable detail so as to make their usage crystal clear. Thus the volume, which is called a dictionary, is actually more of an encyclopedia, of interest to anyone working on missiles or space vehicles.

The scope of the book becomes evident upon even a cursory rundown of the terms discussed. Included are the names of missile and space vehicles, and the guidance and control, propulsion, armament, and launching systems of which they are composed; the components which make up these systems; and related terms from the fields of aerodynamics, electronics, astronomy, and physics, the last group including terms dealing with antennas, circuits, radar, rockets, and propellants, as well as the major laws, relationships, and concepts which govern their use.

In short, this dictionary covers the field from "A" (17 different definitions, ranging from "linear acceleration [a]" to magnetic vector potential "[A]") to "Zuni" ("a U.S. Navy 5-in. high velocity rocket for air-to-air and air-to-ground use . . .").

In addition, cross-referencing is extensive, facilitating the ability of the user to follow up a particular term when he is seeking additional information. Also, the simplest possible indexing arrangement has been employed, which means that any term sought can be found by riffling through a minimum number of pages.

In his preface, Capt. Merrill notes that "serious omissions may be found and the rigorousness of definition and usage . . . questioned." While the editor and contributing editors thus indicate an awareness of the magnitude of the job they faced, only the most carping critic will deny the worth of this important volume, which represents an important first step toward establishing an Esperanto of missile and astronautical terminology.

—**Irwin Hersey**

BOOK NOTES

Soviet Space Science by Ari Shternfeld (361 pages, Basic Books, $6) puts in permanent and readily available form the excellent Russian introduction to spaceflight reviewed in the December 1958, ASTRONAUTICS, and previously available only from the Office of Technical Services in multilith form. Dressed up with a foreword and epilogue by Willy Ley, and with photos and illustrations much improved over the OTS version, the book provides a straightforward account of just what it takes to launch a satellite and also considers man in space, tracking and communication problems, satellite re-entry, and interplanetary flight. Drawing largely on Western source material, the book offers little insight into what the Russians are doing, but does provide a good rundown on astronautics by one of the best Soviet popular writers in the field.

The Soviet Air and Rocket Forces, edited by Asher Lee (312 pages, Frederick A. Praeger, $7.50), offers a full-scale analysis of Russian air power today. While the book is largely concerned with conventional aircraft, the chapter on Soviet missiles, by the editor and Richard E. Stockwell, provides a careful analysis of Russian achievements in the field of rocketry. The authors' conclusion: The Soviets obviously have enormous rocket engines, but their satellites are less sophisticated than ours and the guidance systems they use are almost primitive by our standards. Sum-up: Of interest primarily to those seeking information on Soviet air power, although a few chapters provide some food for thought about Russian rocketry.

Those of us who have long been seeking a basic book on astronautics for youngsters in the 12- to 16-year-old category will welcome **Space Travel** by G. V. Groves (106 pages, Educational Supply Assn., Esavian House, 181, High Holborn, London, W.C. 1, $1.35). The author, a British physicist working on high altitude rocket research, has here written an easy-to-read, well-illustrated primer ranging all the way from rockets and how they work to the problems of manned space flight. The first five chapters provide background information on rocketry, the sun, moon, and planets and some of the difficulties involved in man's leaving the earth, while the last five trace astronautical progress from the work of the pioneers to the present day. Dr. Groves, in this handsomely produced little volume, has given American science writers aiming at this field a good target to shoot at.

Mathematics Dictionary, 2nd edition, edited by Glenn James and Robert C. James (546 pages, D. Van Nostrand, New York, $15), revises and enlarges the dictionary issued in 1949. It now gives definitions of more than 7000 mathematical terms and includes indexes in Russian, German, French, and Spanish as well as English—an unusual and valuable feature for researchers and librarians. The book covers elementary terms in arithmetic, geometry, alegebra, and calculus as well as advanced mathematics, such as the calculus of variations and point-set topology. It includes many new terms developed, for instance, for the theory of games and linear and dynamic programming. The book should thus serve both as a working guide for research groups and libraries and as a general reference.

RECEIVED

Materials for Rockets and Missiles by Robert G. Frank and William F. Zimmerman (124 pages, Macmillan, New York, $4.50).

Fundamentals of Radio Telemetry by Marvin Tepper (116 pages, John F. Rider, New York, $2.95). Paperbound.

Fundamentals of Nuclear Energy and Power Reactors by Henry Jacobowitz (144 pages, John F. Rider, New York, $2.95). Paperbound.

Nitroparaffins and Their Hazards (59 pages, National Board of Fire Underwriters, 85 John St., New York 38). Paperbound research report.

Engineers' Job Directory 1959 (72 pages, Oliver P. Bardes, 4600 Red Bank Rd., Cincinnati 27, Ohio, $5.00). Includes student's summer job index and information on resumes.

RCA Receiving Tube Manual, Revised Edition (Commercial Engineering, RCA Electron Tube Div., Harrison, N. J., 75 cents).

The Language and Symbology of Digital Computer Systems (Govt. Service Dept., Bldg. 210, RCA Service Co., Camden 8, N. J., $2.00 postpaid).

Celestial Mechanics by E. Finlay-Freundlich (150 pages, Pergamon Press, New York 22, $7.50). A compact discussion on contemporary ground.

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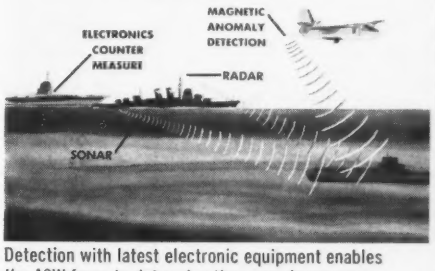

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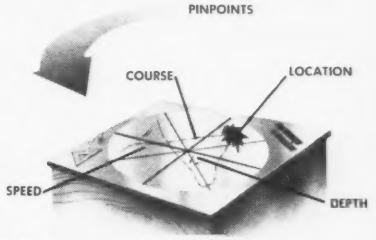

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Missile market

BY JEROME M. PUSTILNIK, Financial Editor

AS THE Dow-Jones Industrials pushed to a record high of 644 in May, for a gain of 3.2 per cent, missile shares experienced a mild correction. The Missile Index closed the month down 3.1 per cent.

The decline actually was more precipitous than the figures show. Litton and Thiokol, for example, climbed briskly for a time, after the May index was computed. It was this loftier level from which they tumbled. Nonetheless, the divergent movements, about which we've often spoken, continued as Martin and Bendix each appreciated more than 10 per cent in the past month.

The uninterrupted ascent of missile industry shares had been far too swift, and last month's reaction was overdue. But the chorus of approval—one might almost say glee—greeting the group's decline *was* surprising. Financial observers jostled Wall Street analysts in their rush to report that the surge in space stocks was over, and the madness for missiles was finished. These comments tell that their authors are unwisely selling our industry short. For it's not popular fancy and fads, but vigorous growth that is the industry's propellant. Public enthusiasm, swelling and then waning in its notoriously fickle way, exaggerates market movements—particularly evident in missile issues the last few months—but fundamental growth will be the final arbiter.

Ideally, these distortions would not exist and market prices would rise gradually and steadily. But they do exist. And we must expect periods of undervaluation to follow overvaluation. This cycle will repeat itself. But long-term investors can become richly rewarded when they ignore the ebb and flow of popular fads, together with the abortive market moves they inspire, and, instead, concentrate on a company steadily increasing its participation in the missiles program and with years of growth ahead.

Aeronca Manufacturing seems to fit that description. A major producer of aircraft subassemblies, Aeronca also turns out parts for various home appliances. But military subcontracts are the major part of its business. Usually regarded as part of the aircraft group, Aeronca supplies subassemblies for the Boeing 707 Jet Liner, the B-52G, and the KC-135. The company has also received important contracts for the Air Force's two new Mach 3 aircraft programs, the North American B-70 "Valkyrie" and the F-108 long-range fighter-interceptor.

	June 1959	May 1959	% Change	June 1958	% Change
Dow-Jones Industrials	644	624	+3.2	463	+39.2
Missile Index	1093	1128	−3.1	620	+76.3

Both of these aircraft, designed to attain speeds greater than 2000 mph, are large consumers of brazed stainless-steel honeycombing. Management feels Aeronca, a leader in this swiftly expanding field, could enjoy years of growth in this area alone.

In February 1959, the company merged with Longren Aircraft of Torrance, Calif., a producer of aircraft subassemblies. Through this acquisition, Aeronca obtained much needed West Coast facilities, near their primary customers. Increased subcontract business could follow this step.

With the award to Aeronca of the prime contract on the Pogo-Hi, a liquid-fueled target missile, another potentially significant development was disclosed. The Air Force has indicated it believes the company has a missile systems capability.

In the new-products area, the company's Baltimore division, its electronics research facility, has introduced a standard-to-binary translator for electronic counters and other output devices. Activities in ultraviolet and digital telemetering equipment are being expanded.

Aeronca's backlog totaled $41.2 million at the beginning of 1959, compared with $32.3 million a year earlier. Company executives have indicated the backlog has continued to rise.

Sales should exceed $29 million this year, company officials have said, a handsome gain over 1958's $23.1 million. Earnings will be about $1.10 a share (allowing for the dilution from the Longren Aircraft acquisition), a modest increase from the $1.04 of last year. Sales and earnings should grow more vigorously over the next few years as Aeronca benefits from its new products, its propinquity to its major customers, a larger role in missile programs, and the surging use of brazed stainless-steel honeycomb structures. To conserve capital for this growth, the company pays a small stock dividend in lieu of cash.

Aeronca has no long-term debt. Two small preferred stock issues are the only securities senior to the 507,689 shares of common stock, which are traded on the American Stock Exchange.

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- ☐ MATERIALS
- ☐ SYSTEMS ANALYSIS
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Mechta Radiation Data

(CONTINUED FROM PAGE 23)

the medium dynodes.

Both Geiger counters and the first scintillation counter were located inside a housing of aluminum 1.0 gr/cm² thick. In addition, about 20 per cent of the total solid angle was screened by a large quantity of matter ($\sim$10 gr/cm²). The second scintillation counter was located outside the housing. The scintillator, 0.3 gr/cm² thick, was covered on the side of free space by an aluminum foil 1.9 mg/cm² thick.

The cited device was used only for measuring the total ionization. In the case of recording an electron stream with energies within the range of 100–1000 kev, the indications of the device would give an energy flux carried by these particles within a solid angle of 1.8 sterad. The electronics of all devices (amplifiers, computing schemes, and elements for coordination with telemetry) were made with semiconductors. The resolving power of the converting cells was 10^{-4} sec.

This article will deal with results of preliminary processing of data related to a distance range of 8000–150,000 km from the earth's center.

Inasmuch as the motion of particles is determined by the magnetic field, it is natural to represent the results of measurement of the emission intensity not in geographical, but in geomagnetic, coordinates. The chart on page 23 shows the trajectory of the motion of the rocket in relation to the terrestrial magnetic field.

It can be seen that the maximum radiation intensity is reached at a distance of about 26,000 km from the earth's center. At a distance of 55,000 km, the intensity of the terrestrial corpuscular emission becomes practically equal to zero. (It will be shown below that the residual ionization at this point, which does not vary in further flight, is entirely due to cosmic radiation.)

It is obvious that the intensity is determined not only by the distance from the earth's center, but to no less extent by what magnetic force line the measurement occurs on. Since the motion of particles should occur along a spiral winding along a force line, knowing the intensity in some point of a given line should make it possible to draw quantitative conclusions as to the intensity in its other points.

Thus, for example, from the fact that the intensity along the force line 70 deg (we shall designate a force line by the geomagnetic latitude on which it intersects the terrestrial surface) in the intersection point of the

force line with the rocket trajectory (R=53,000 km) is close to zero, it follows that along this force line, the intensity is also close to zero. We assume here that the particles perform oscillations along the force lines symmetrically in relation to the equatorial plane.

An experimental proof of this assumption may be found in that the intensity grows along a specified force line while moving from low altitudes to high ones. Thus, for example, the intensities in various points of the force line of 60 deg for altitudes of 400, 1800, 5600, and 14,000 km over the terrestrial surface have the ratio of 1 : 20 : 200 : 700. (The data for the two first altitudes were obtained by the third satellite.)

Such intensity variation along a force line indicates that the particle stream is not directed one way; in any case, a major part of the particles undergoes full reflection upon approaching the earth and correspondingly performs oscillations from one hemisphere into the other. In this process, oscillations of lower amplitude are represented by a larger amount of particles. This may be explained in that the lifetime and, accordingly, the factor of agglomeration decreases with growing amplitude, in particular, because of absorption in the denser atmospheric layers.

Sputnik III Experiments

In our experiments carried out with Sputnik III, it was revealed that the terrestrial corpuscular emission should be divided into two zones, differing in their spatial distribution, as well as in the composition of the particles. With regard for the relatively low altitude of the satellite flight, these zones have been called the polar and the equatorial zones. In analyzing this phenomenon, it seems better to call these zones the internal and the external. The boundary of the equatorial (internal) zone passes at an altitude of 1000 km at a latitude of 45 deg, and it is natural to assume that from the high-altitude side the boundary of this zone is formed by the force line of 45 deg.

The chart on page 23 shows that the rocket trajectory nowhere intersects the internal zone. And, indeed, as it will be shown below, the cosmic rocket devices did not in any part of the trajectory record high-energy particles characteristic for the internal zone. (These particles in the internal zone seem to be protons, produced by neutron decay.)

On the other hand, the composition of the emission appeared to be rather close to that observed by Sputnik III in polar regions. This satellite revealed at altitudes of 400 and 1800 km a rather sharp boundary of the polar zone of high intensity at latitude $\sim$55 deg. As can be seen in the chart on page 23, during the flight of the cosmic rocket at an altitude of about 7000 km, when the trajectory approaches the force line of 55 deg, there is a tendency to an intensity decrease. Therefore, the external zone of the terrestrial cospuscular emission should be imagined as located in the space between force lines $\sim$ 55 deg and $\sim$ 67 deg. The maximum intensity is observed on the force line $\sim$ 62 deg.

The graph on page 23 shows the instrument readings in relation to the distance from the earth's center. For the curves I, II, and V, a correction is introduced for miscounts, with application of calibrations carried out before launchings. In the region of maximum radiation the tempo of counts along the channels I, II, and V is close to saturation. Thus, the correction for miscounts becomes uncertain, and in this region the curves are disrupted.

Since the spectrum of pulses in the scintillation counter appeared to be very soft, and the resolving time of the discriminators was 10^{-4} sec, it is indispensable to take under consideration the possibility of overlapping of pulses in time.

By using the section 40,000–50,000 km, we may obtain the following evaluation of the spectrum: N($>$ 45 kev); N($>$450 kev); N($>$4.5 mev) = 1 : 10^{-2} : 10^{-5}. These data and the comparison of the counting tempo and ionization show that the basic part of energy falling on the crystal belongs to X-rays of $\sim$100 kev energy or less. Further improvement of the spectrum may be realized by taking into account data from the Geiger counter. During calibration within the energy range of 20–100 kev, our counter indicated, in comparison with the ionization measurement (IV), a rising efficiency at a lower hardness of X-rays. Therefore, the correlation of the counter indications and the ionization provide an opportunity for evaluating the effective energy of X-rays. This evaluation yields 50–60 kev for the altitude range of 40,000–50,000 km. Therefore, the ionization produced under the casing occurs on account of radiative capture produced in the electron absorption of $\sim$50 kev energy in the screening aluminum casing.

The graph on page 23 gives some indication that the electron spectrum is not constant at various altitudes. This is shown by the varied behavior of curves IV and V. In the maximum region, at distances of 11,000–36,000 km from the earth's center, the ratio of ionization to number of counts by the counter decreases, which circum-

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stance, as mentioned above, indicates a decrease of X-ray hardness. The evaluation of hardness at the maximum of the measurable value of counting (at a distance of 12,000–33,000 km) gives a value of 25 kev.

Therefore, there are some indications that in the middle of the external zone, where the particle density is highest, the effective electron energy is minimum. The existing rise of Curve III, in the range of 20,000–30,000 km, does not show the appearance of high-energy particles, because such behavior of the curve is explained by pulse overlapping at the intensity which occurs at the maximum.

In the region of the maximum, the hardness evaluation may be processed by introducing the data of the second scintillation counter. This counter measured at maximum intensity an energy flow of 2×10^{11} ev/cm^2 sec sterad. The energy flow under the aluminum layer of 1 gr/cm^2 (according to data IV) equals $1.5\ 10^9$ ev/cm^2 sec sterad.

The correlation of the measured energy flows is determined by the aspect of the energy spectrum of incident electrons. By keeping in mind that the second counter effectively records only electrons with energy over 50 kev, while the effectiveness of the first counter within the range 20–100 kev varies considerably more loosely, an evaluation of the spectrum aspect in the specified energy range can be made: If we represent the integral energy spectrum of electrons in the form $N(>E) \sim E^{-\gamma}$, then $\gamma \sim 5$. For sections with lower intensity, on the edges of a zone, the spectrum is noticeably harder ($\gamma \sim 3$).

We should remark that the energy flow measured by the second scintillation counter does not quite agree with data obtained by Van Allen on the fourth U.S. satellite. These measurements yielded an energy flow of 10^{13} ev/cm^{2}sec/sterad. The difference in the foil thickness (in the device of Van Allen 1 mg/cm^2) can hardly explain a difference by a factor of 100, which is even further widened by the large difference in flight altitude. If we do not consider the essential difference in time and the locale of the experiment, which makes comparison more difficult, but consider the cause for the divergence to be the different thickness of the foil, then we could assume the presence of slow neutrons with paths in the range of 1.0–1.9 mg/cm^2.

As seen from the graph on page 23, during recession of the rocket from the earth, starting with a distance of 66,000 km, the intensity of all components remains constant. The slight monotonic lowering of Curve IV is not a response to variation of ionization, but appears to be an instrument effect connected with the long afterglow of the crystal NaI(TI). The strict stability of the intensity of all components in the range of distances 66,000–150,000 km shows that we are dealing with emission on which the terrestrial magnetic field has no effect at such distances. This signifies that either the terrestrial magnetic field "disappears" at a distance of 10 radii (for example, because of the existence of an interplanetary field of strength 3×10^{-4} oersted); or in the cosmos–more accurately, in interplanetary space–particles of energy within the range $1.5 \times 10^8 - 4 \times 10^7$ ev/c are missing, if we assume that the dipole field extends to 20 earth radii.

The number of charged particles of cosmic rays recorded by the Geiger counter is 2.3 particles/cm^2/sec; and, according to the scintillation counter (Curve III of graph on page 23), it is 1.9 particles/cm^2/sec. The slight difference of these data is explained by the fact that the relativistic proton, passing through the edges of the crystal, may lose the energy below the threshold energy of 4.5 mev. The introduction of a correction for the decrease of effective cross section of the crystal sets these data in agreement.

Therefore, the flow of primary cosmic particles is 2.3 ± 0.1 particles/cm^2/sec–the error characterizes the uncertainty in the dimensions of counter and crystal–or 0.18 ± 0.008 particles/cm^2/sec sterad. This value agrees well with measurements carried out on balloon sounds in the stratosphere at high latitudes, and shows that the somewhat high value of intensity in rocket tests is connected to the albedo from the atmosphere.

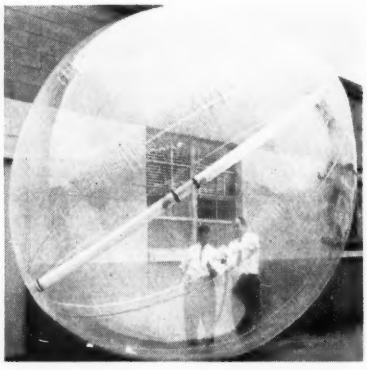
The photon intensity (after deduction of pulses bound to penetrating particles) amounts, within the range of 45–450 kev, to 3.2 ± 0.1 photons/cm^2/sec and, within the range of 450–4500 kev, to 1 ± 0.1 photon/cm^2/sec. These numbers give an evaluation of intensity of the X-ray and gamma emission in cosmic space. However, it is not excluded that a significant part of the recorded photons, particularly within the range of 450–4500 kev, is produced by cosmic rays in the matter surrounding the crystal. The role of this effect is at present being defined more accurately.

The photon energy flux is rather low and introduces practically no contribution to ionization. The ionization in the crystal is $1.42\ 10^9$ ev/sec or 8×10^6 ev/g/sec; the mean ionization of particles is 3.5×10^6 ev/cm^2/g, which exceeds by 2.5 times the minimum ionization in NaI. The higher ionization is explained well by the presence in the composition of primary cosmic rays of α-particles and heavier nuclei, taking into account that a part of them are not relativistic.

Upper-Atmosphere Drag Sphere

A unique balloon ejected from a two-stage rocket will soon make it possible to measure drag directly at altitudes up to 300 miles. The balloon, an inflatable dacron-reinforced plastic sphere, carries an accelerometer sensitive to 10^{-5} g and telemetering equipment in an aluminum can at the center of a diametric inflatable plastic strut. The whole equipment forms an 18-lb package that will be ejected at an altitude of 60 miles by a Sparrow mounted as second stage on an Aerobee booster. The balloon and strut will then be inflated by evaporating charges of ethyl alcohol and freon, respectively, and soar along the trajectory of the rocket to the programed altitude. It will take 7 or 8 min to reach a zenith of 300 miles, telemetering as it goes.

The system was designed and developed by Arthur D. Little Inc. for AFCRC Geophysics Research Directorate. The Univ. of Michigan designed the special accelerometer.



This dacron-reinforced plastic sphere, developed by Arthur D. Little, Inc., for AFCRC, carries an accelerometer sensitive to 10^{-5} g and telemetering equipment for measuring drag at altitudes up to 300 miles.

...NEWS IS HAPPENING AT NORTHROP

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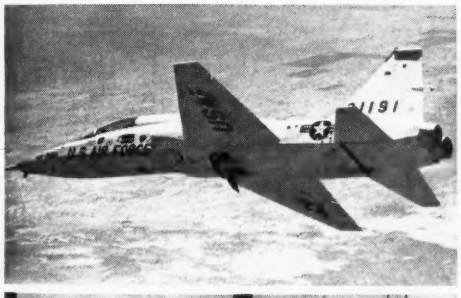

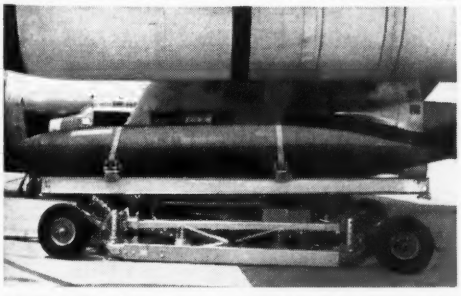

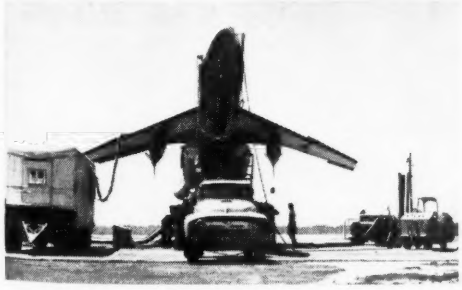

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(CONTINUED FROM PAGE 35)

included in a design. Finally, a reduction in the number of components needed to accomplish the several functions will always be an advantage from the overwhelmingly important standpoint of reliability.

The satellite design presented here has been evolved from a series of design exercises carried out over the past three years. It was clear at the outset that the environment in which a satellite re-entry vehicle needs to operate required a fresh look at basic structural design. History shows us that extrapolations from one medium to another can be very misleading and bring undesirable results. This certainly was the case for Francesco Lana, who in 1670 tried to extrapolate his knowledge of boats into a medium one thousand times less dense. The flying machine design which resulted from his efforts was reminiscent of sailboats of that era. Similar extrapolation's of our knowledge of aircraft and missiles, which operate in dense air, into an environment where the air is ten thousand times less dense, result in manned re-entry vehicles not unlike high-speed aircraft. It seems to us that extrapolations of today's airplanes or missile nose cones will be as misleading as Lana's design effort.

We set ourselves the task of designing a structure compatible with the environment in which it must operate. Investigation revealed the ability of drag variation to serve as the basic landing point control. As a result, the complexities of lifting vehicles were discarded in favor of a series of variable-drag devices, which have been termed "drag brakes." Continued engineering effort in the design of lightweight foldable structures has resulted in an inverted umbrella-like design.

The manned satellite design proposed is built around the stainless-steel drag brake shown on page 35. Opening and closing the structure in orbit results in a 20:1 drag variation. This drag variation causes a corresponding change in the rate of descent or orbital lifetime. Controlled variation of the drag according to a preset program permits landing at a preselected point with an accuracy of $\pm$ 150 n. mi. The extended structure has a low loading, only $1^1/_2$ lb/ft^2, and consequently the vehicle decelerates high in the atmosphere, and radiates re-entry heat away at temperatures which never exceed present gas turbine practice.

It is a fortunate coincidence that the drag brake also yields a sufficiently low terminal velocity that no additional parachutes are required for landing at ground level.

Thus we propose a single new component, the drag brake, which performs a multiplicity of functions that are performed by individual systems in other designs. In addition to the obvious reliability advantage, this simple component brings very substantial weight savings.

Let us look further into the drag brake satellite's design and performance, narrow our discussion by omitting problems of human engineering, such as cabin ecology, emergency escape, and communications, and treat only aspects which differ from the retrorocket approach.

Folded on Booster

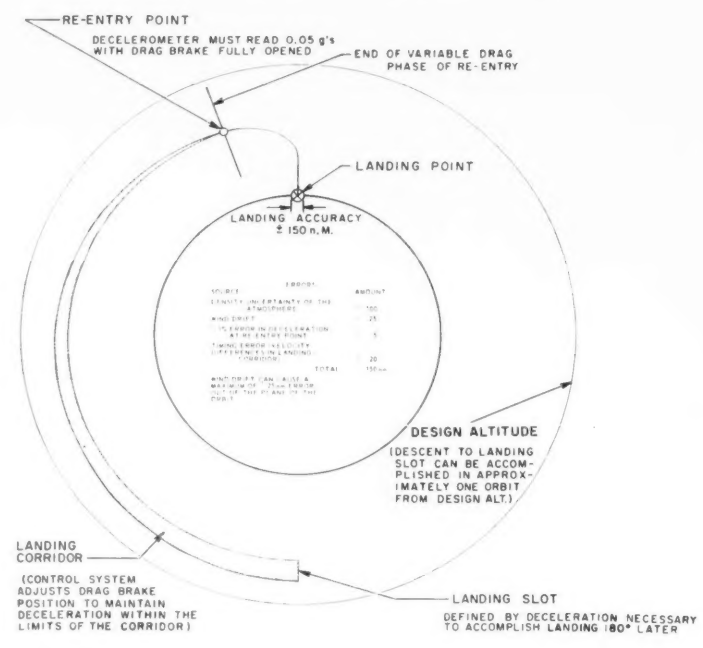
During launch, the drag brake satellite is mounted on the booster in the folded position, as illustrated on page 35. The man lies in the recommended supine position on a contoured couch inside the capsule. The flexible drag brake covering is carefully folded inside the ring of ribs. A tractor-type escape system is mounted at the forward end of the ribs. The drag brake is covered by a protective nose cover. At staging, when the vehicle is essentially out of the dense part of the atmosphere, the nose cover and escape system are jettisoned.

The booster vehicle accelerates the satellite until the proper velocity vector has been achieved. Then the satellite and booster are separated gently and the drag brake vehicle starts its journey in space. The satellite will be launched into a 105 n. mi., near-circular orbit. This orbit allows a lifetime of two days in the low drag, or closed position, of the drag brake and also allows emergency recovery in 2 hr. It should be pointed out that emergency recovery times of less than the orbital period do not make sense because recovery must be effected at a specific point in every orbit in order to minimize the vast problem of location after landing.

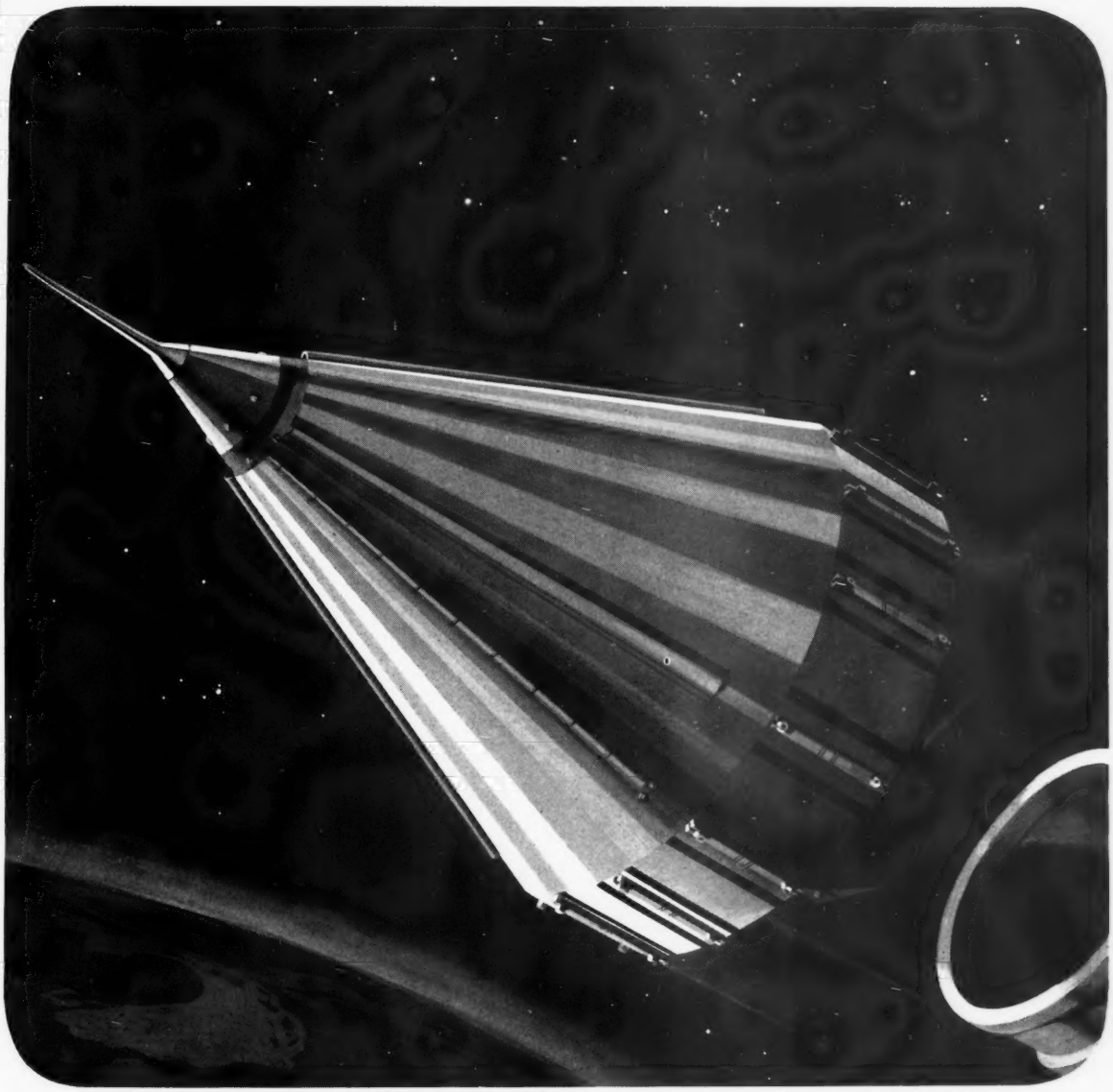
At 105 n. mi. the small but distinct amount of residual atmosphere exerts forces on the vehicle. Because of the large extended structure of the brake, even in the closed position, these forces are sufficient to exert the necessary movements to orient the vehicle into the air stream. The period of this motion at 105 n. mi. altitude is several minutes.

For a drag brake satellite, re-entry is made up of a number of distinct phases. First, the satellite descends from the orbital altitude to the region from which a controlled re-entry is made. Next, the drag is controlled according to a preset program for about half an orbit in order to achieve a given velocity vector at a particular point. Finally, the drag brake is fixed

Schematic of Landing Point Control


RE-ENTRY POINT
DECELEROMETER MUST READ 0.05 g's WITH DRAG BRAKE FULLY OPENED
END OF VARIABLE DRAG PHASE OF RE-ENTRY
LANDING POINT
LANDING ACCURACY ± 150 n.M.
DESIGN ALTITUDE
(DESCENT TO LANDING SLOT CAN BE ACCOMPLISHED IN APPROXIMATELY ONE ORBIT FROM DESIGN ALT.)
LANDING CORRIDOR
(CONTROL SYSTEM ADJUSTS DRAG BRAKE POSITION TO MAINTAIN DECELERATION WITHIN THE LIMITS OF THE CORRIDOR)
LANDING SLOT
DEFINED BY DECELERATION NECESSARY TO ACCOMPLISH LANDING 180° LATER

NOTABLE ACHIEVEMENTS AT JPL . . .



PIONEERING IN SPACE RESEARCH

Another important advance in man's knowledge of outer space was provided by Pioneer III. This, like many others of a continuing series of space probes, was designed and launched by Jet Propulsion Laboratory for the National Aeronautics and Space Administration. JPL is administered by the California Institute of Technology for NASA.

During its flight of 38 hours, Pioneer III was tracked by JPL tracking stations for 25 hours, the maximum time it was above the horizon for these stations.

The primary scientific experiment was the measurement of the radiation environment at distances far from the Earth and telemetering data of fundamental scientific value was recorded for 22 hours. Analysis of this data revealed, at 10,000 miles from the Earth, the existence of a belt of high radiation intensity greater than that observed by the Explorer satellites.

This discovery is of vital importance as it poses new problems affecting the dispatch of future vehicles into space. The study and solution of such problems compose a large part of the research and development programs now in extensive operation at the Laboratory.

jpl

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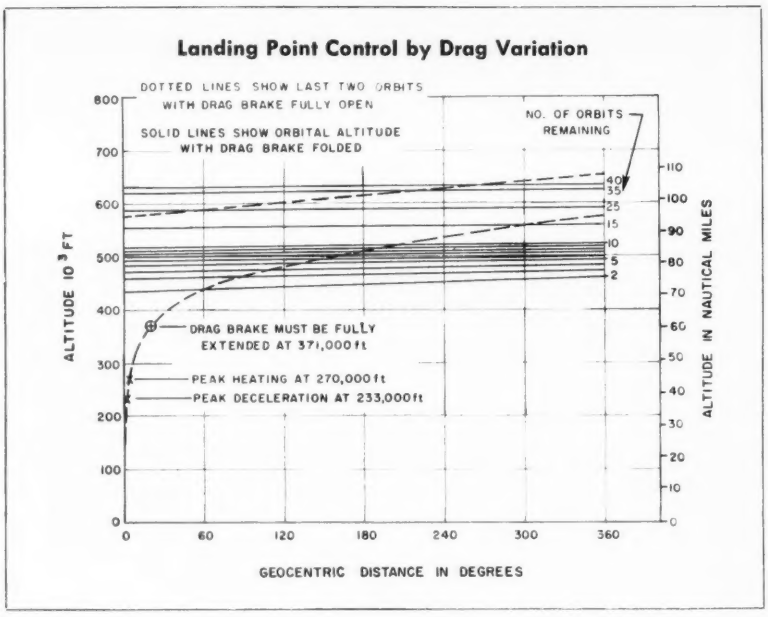


in the open position at the onset of serious heating and the vehicle passes through the heating and deceleration peaks and achieves terminal velocity at about 200,000 ft. From here down the vehicle drifts at terminal velocity and lands at 50 fps at sea level.

The principle of operation of the variable-drag landing point control is shown above. This concept depends simply on the fact that the descent rate or lifetime of decaying satellite orbits can be changed significantly by changes in the vehicle ballistic parameter W/C_DA. For instance, from an altitude of about 90 n. mi. one can re-enter in as many as 15 orbits or in less than one orbit, depending on the drag brake position, i.e., ballistic parameter W/C_DA. It can be shown that a large amount of control is available by a 20:1 drag variation. In fact, in the geometric mean drag brake position, and only 3000 n. mi. from the landing point, one can still alter the landing point by approximately +2000 and −1500 n. mi.

Control System Philosophy

A detailed control system philosophy which operates on the above stated principle has been developed. The system depends on two very simple measurements—time and acceleration. The time serves to locate the vehicle with respect to the landing point. As long as the satellite is still in a nearly circular orbit, the orbital period is essentially invariant with the small ellipticities due to drag and drag variations. Thus, the timing from either the insertion point or from a later fix locates the satellite accurately. This relationship holds until the onset of large deceleration forces. Thus, ideal or nominal drag variation with time can be established for the controlled drag phase of re-entry. A body-mounted accelerometer measures this drag and compares it to the measured drag and to the nominal value desired. The control system can then sense whether the drag is correct, too high, or too low and can produce signals which vary the drag brake position so as to eliminate the difference between the nominal and measured values. It should be pointed out that this system does not require accurate information about the orbit, and therefore the tracking requirements are simplified.

This control system is capable of correcting the effect of ellipticity, altitude error at the start of the controlled phase, errors in our knowledge of the upper atmosphere, and density variations of either the latitude or diurnal type. The result of an error analysis fixes a density range from which the control system is able to achieve a landing point accuracy of ±150 n. mi. in the orbital plane. This is indicated by the "landing slot" shown on page 90. During the controlled phase the satellite flies within the "landing corridor," correcting the drag brake position in accordance with the control system dictates, until it achieves the proper velocity vector at the re-entry point.

From the re-entry point to final touchdown, no further functions are required. The nose of the capsule has heated up to a temperature of about 500 F, and the vehicle is now only 1000 n. mi. from the final landing point. Up to this point, the linear relationship between distance and time have been accurate to ±20 n. mi. At the low drag parameter (W/C_DA) of 1.5, peak heating occurs at a very high altitude, and consequently the heat transfer rates and the radiative equilibrium temperatures are relatively low. The maximum temperature encountered by the structure at the capsule nose surface is less than 1500 F, assuming an emissivity of 0.85. The drag brake surface, which can radiate from both the front and rear surfaces, never exceeds an equilibrium temperature of 1200 F. At peak heating, reached at 270,000 ft altitude, the deceleration is about 4 g. After peak heating the deceleration continues to increase and reaches 8.2 g at 233,000 ft. The time above 8 g is approximately 20 sec, and is well within the established limits of human endurance. At peak deceleration the maximum temperature has already decreased to 1130 F, as indicated in the graphs on page 96.

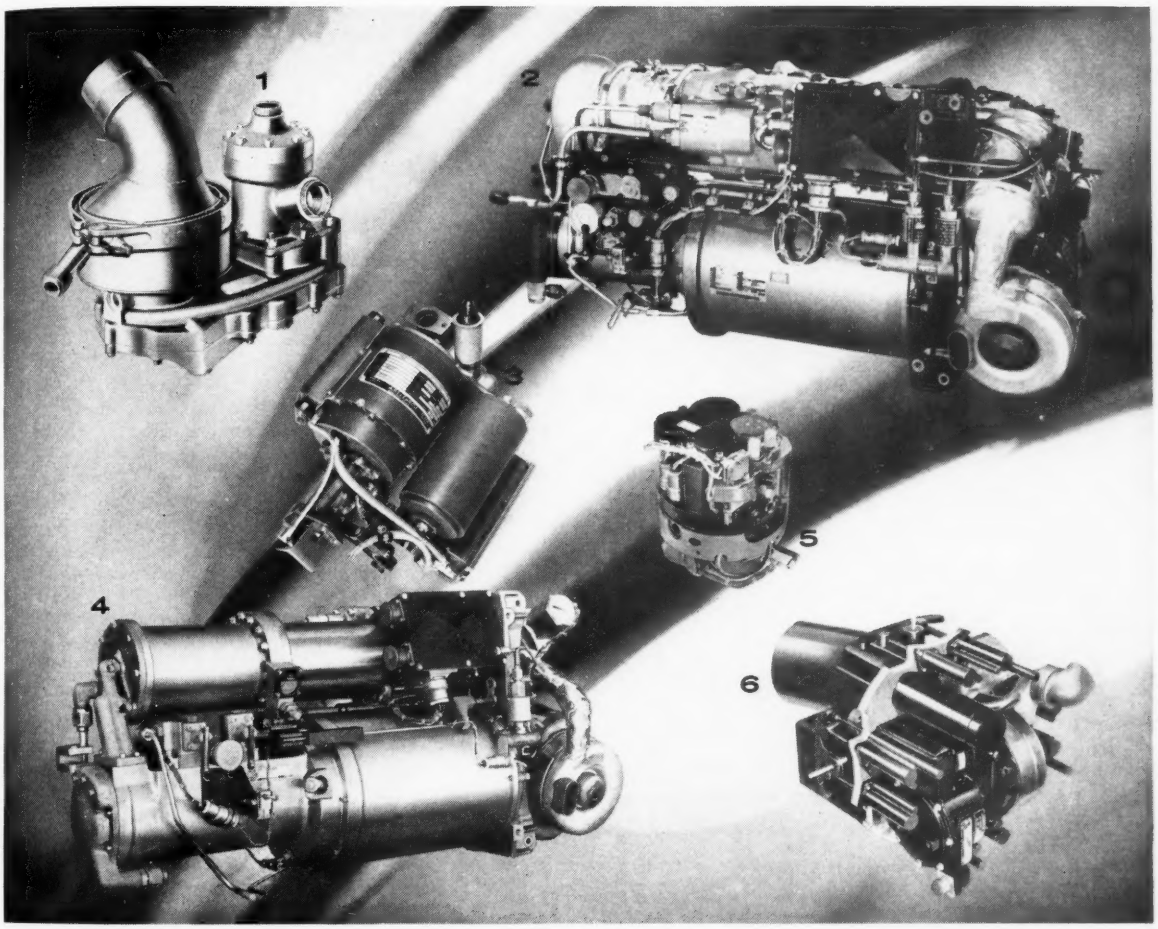
The relative time of occurrence of the peaks of heating and deceleration point out an interesting possibility for future drag brake vehicles. If at the instant of peak heating (i.e., 4 g) the acceleration is held constant by retracting the drag brake slightly, then the peak re-entry deceleration can be reduced to 4 g without any increase in maximum temperature. The peak heating condition would merely be held for a somewhat longer time, which does not penalize a radiating re-entry vehicle structure.

Terminal Velocity

The drag brake continues to decelerate and approaches terminal velocity just under 200,000 ft. The terminal velocity decreases with increasing air density until at sea level the vehicle lands at 50 fps. During the terminal descent, which takes approximately 15 min, the large metallic surface is an excellent radar target for tracking and locating the vehicle at the landing.

The mechanical problems of building a drag brake satellite system have been faced in some detail. The device consists of four basic components, i.e., the ribs, the covering material, the actuating mechanism, and the capsule. Of these, the ribs represent over 50 per cent of the total weight of the drag brake, and consequently have been analyzed in most detail. The total weight of the ribs could be reduced by decreasing the number of ribs. However, the consequent departure from a true spherical surface due to the scalloping effect of the covering between the ribs would increase the heat trans-

DELIVERED—thousands of missile APUs



1. *Solid propellant—hydraulic output* **2.** *Liquid propellant—hydraulic and electric output* **3.** *Solid propellant—electric and mechanical drive output*
4. *Liquid propellant—hydraulic and electric output* **5.** *Solid propellant—hydraulic and electric output*
6. *Solid propellant—hydraulic, electric and steering outputs*

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The several units pictured above provide hydraulic, electrical and/or steering surface control depending on the customer's requirement. Delivered horsepower ranges from 1.2 to 35 h.p. over hot gas operating durations from 30 seconds to 20 minutes. Electrical regulation is maintained as closely as ± ½%. A significant advance in missile APUs is unit #6 pictured above. This package represents the first integrated hydraulic and electrical power unit providing a steering surface actuation system.

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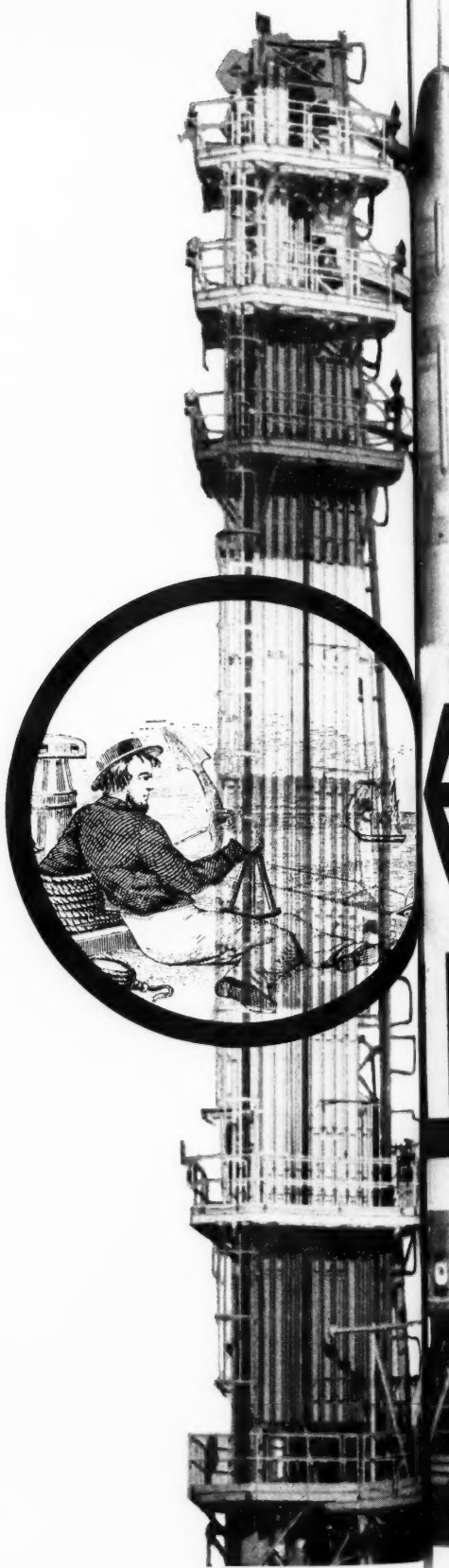

PORT OF EMBARKATION

In the decade of missilery ahead, prime contractor capability must go far beyond the requirements of hardware design and manufacture. New experience and facilities are now required in the increasingly critical launching phase—from ground handling and testing to countdown and data control.

Martin's Cocoa Division is the first organization of its kind devoted exclusively to this specialized area. Accomplishments have already established new operational standards at Cape Canaveral, one of the two U.S. ports of embarkation for the major space events of the decade ahead.

An example of the latest development in electronic fail-safe launching equipment is the new Martin Master Operations Control [MOC] system, which automatically monitors count-down procedures in the test firing of research and development-type TITAN missiles. With equipment such as this, TITAN launchings have achieved unheard-of performance reliability.

The Cocoa Division
is one of the
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fer on the ribs. The ribs are 0.020-in. stainless-steel beams with reinforcing cap strips. Buckling due to compression of the cap strip is the most critical design condition.

The covering material must be as light as possible. Stainless-steel cloth made of 0.001-in. wire woven into a close, 400 by 400 mesh is commercially available. This material meets all the requirements except that it is somewhat porous. Even a small amount of porosity increases the heat transfer on the drag brake significantly due to the removal of the cool boundary layer air blanketing the surfaces.

Several methods of reducing the objectionable porosity are under consideration. It is presently possible to build up a drag brake skin out of a layer of the above cloth, then a layer of thin (0.0005 in.) solid sheet but cut into circumferentially aligned ribbons or shingles, and finally another layer of cloth of a coarser mesh. The shingles will eliminate the porosity, yet are flexible enough to satisfy the folding requirements. The two layers of cloth maintain the shingles in place and prevent tearing. The air loads can actually be transmitted to the ribs by any one of the three layers alone.

Light Structures

The actuating system and capsule do not represent serious design problems. It is mostly a question of arriving at the lightest and simplest structure for each. Actuation can be either pneumatic, electric, or mechanical. A two-way pneumatic system is presently proposed. The pneumatic system has the advantage for manned vehicles of not requiring any components inside the capsule and allowing for explosive-actuated emergency opening procedures. For applications where the capsule geometry restrictions are less severe than in the manned vehicle, mechanical systems may be better solutions.

The optimum pressure vessel, a sphere, is nearly a compatible capsule shape for the drag brake vehicle. Only a slight conical section need be interposed between the spherical top and bottom halves. The conical section is extended both up and down to form the hinge points for the drag brake. This capsule weighs only a few per cent more than an equivalent spherical vessel.

One more design consideration which is peculiar to the drag brake must be discussed. In this design the configuration was dictated by the orbital, re-entry, and escape conditions, rather than by the sea level landing speed. The resultant landing velocity of 50 fps is somewhat higher than has

People in the news

APPOINTMENTS

President Eisenhower has named **George Bogdan Kistiakowsky,** professor of chemistry at Harvard Univ., to succeed James R. Killian Jr. who resigned as Special Assistant for Science and Technology.

Joseph V. Charyk, AF chief scientist, has been nominated as AF assistant secretary to succeed **Richard C. Horner,** who resigned to become NASA associate administrator.

Kurt Stehling has been appointed assistant to Homer J. Stewart, NASA director of program planning and evaluation. He was formerly head of the Vehicles Branch at NASA's Goddard Space Center.

John P. Hagen, chief of NASA's Vanguard Div., has been appointed assistant director for program coordination for the agency. **Milton B. Ames Jr.,** former chief, Aerodynamics and Flight Mechanics Div., becomes assistant director of aeronautical and space research (aeronautics and flight mechanics), while **David H. Newby,** chief of the Army Ordnance Corps Test and Evaluation Lab, Redstone Arsenal, becomes NASA representative at AOMC.

Robert M. Lawrence, ARS treasurer, has been appointed assistant to the treasurer and controller of Thiokol Chemical Corp. **W. M. Mebane,** becomes secretary, and is succeeded by **Joseph W. Wiggins,** assistant divisional manager, as manager of the Redstone Div. **James T. Grey,** former scientific adviser to the director of R&D, USAF Headquarters, has been appointed director of Thiokol's research planning staff, Rocket divisions.

Col. Charles H. Terhune Jr., deputy commander for ballistic missiles, has been promoted to vice commander, AF Ballistic Missile Div.

Alan J. Grobecker, project engineer with NAA Autonetics Div., has accepted a one-year appointment with the Advanced Research Projects Div. of the Institute of Defense Analysis.

Joseph G. Logan and **C. J. Wang** have been appointed managers of the Propulsion Research Dept. and Propulsion Systems and Development Dept., respectively, at Space Technology Lab, Inc. **James R. Dunn** and **Morton Goldman** have been named manager and associate manager, respectively, of the Liquid Rocket Engines Dept., Propulsion Lab. **David E. Shonerd** becomes assistant program director for the Minuteman program, and **Arnold R. Anchordoguy,** program director for the Thor weapon system, succeeding **A. K. Thiel,** who is now program director for experimental space projects, R&D Div.

A. John Gale, vice-president and director, applied physics, High Voltage Engineering Corp., is the newly elected president of Goodrich-High Voltage Astronautics, Inc. **P. William Perdriau,** general manager of B. F. Goodrich Aviation Products Div., has been appointed board chairman.

H. Douglas Lowrey has been promoted from director of operations, Chrysler Corp., Missile Div., to assistant general manager of the division.

Joining Aeronutronic Systems Tactical Weapon Systems Div. are **Herbert K. Weiss,** former chief, Weapon Systems Analysis Dept., Northrop Aircraft, as manager of advanced systems development; **Louis H. Brenwald,** former chief of flight test on the Titan ICBM program, as manager of systems test and prototype fabrication; and **John F. Cooney,** former management development manager, Ford manufacturing staff, as manager of administration.

Harold S. Geneen, former executive vice-president of Raytheon Co., has been elected president and chief executive officer of IT&T, succeeding **Edmond H. Leavey** who will serve as board chairman until his retirement this summer.

In a move to decentralize its Data Processing and Military Products divisions, IBM has named **T. V. Learson** vice-president and group executive for the following divisions and their new general managers: Data Systems, **William B. McWhirter;** General Products, **Orland M. Scott;** and Advanced Systems Development, **J. A. Haddad. McLain B. Smith** has been made vice-president and group executive for the following: Data Processing, **Gilbert E. Jones;** Federal Systems, **Charles Benton Jr.;** Supplies, **James E. Swaine Jr.;** and **Frank T. Cary** who becomes president of the Service Bureau Corp., a subsidiary. **Ralph L. Palmer** has been named assistant director for engineering on the staff of the vice-president, research and engineering.

James V. Crawford and **Norman M. Brown** have been named chief engineer and assistant chief engineer, respectively, of Garrett Corp.'s AiResearch Mfg. Los Angeles Div. **Helmut Schelp** becomes chief engineer, **Carl Paul,** assistant chief engineer, and **C. F. Blanding,** engineering manager in the Phoenix Div.

Robert W. Meals, becomes technical representative for Hercules Powder Co., at Redstone Arsenal, and will be succeeded by **Richard Winer,** as assistant manager at Allegany Ballistics Lab.

Roger Newman has joined Hughes Aircraft Co. as head of the Physics Dept. of the Materials Research Lab, Products Group's Semiconductor Div., while **Robert D. Teasdale** becomes head of the Systems Analysis Dept., Ground Systems Group. **Lt. Gen. Stanley R. Mickelsen** (Army-Ret.) joins GSG as technical adviser. **Arthur M. Ross** and **George L. Sansbury** join the engineering laboratory as senior members of the technical staff.

William P. Sloan, has been appointed manager of Ryan Aeronautical's Washington, D. C., office on assignment to the Military Relations Div., and **Vice Adm. Charles F. Coe**

Hagen

Newby

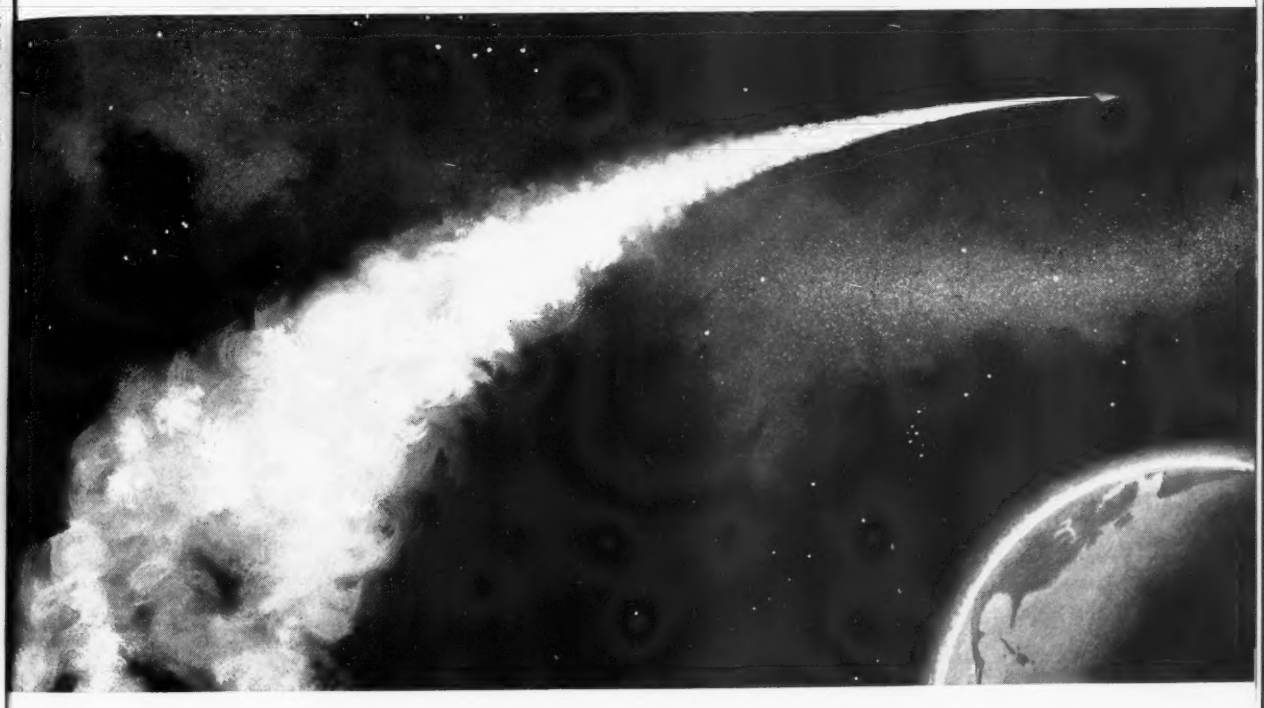
Wiggins

Grey

Gale

Lowrey

DYNA-SOAR



Dyna-Soar (for dynamic soaring) is a joint project between the Air Force and the NASA, and is an attempt to solve the technical problems of manned flight in the sub-orbital regions. Advance knowledge on the project indicates how a boost-glide vehicle can operate from the outer fringes of the atmosphere where it can maneuver and be recovered undamaged. Studies show that by varying the original rocket boost, and thus the velocity, and with the control available to the pilot, the Dyna-Soar aircraft can circumnavigate the earth, followed by a normal and controlled landing. Boeing Airplane Company, one of the competing companies for the development contract for the complete boost-glide system, has delegated to RCA the responsibility for the development of important electronic components of Dyna-Soar.

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(Navy-Ret.), has been named executive adviser to Bruce Smith, vice-president, military relations, and also as military consultant to Sloan.

Murray Shabsis has been upped from senior engineer, guidance and control, to section chief, controls, Solar Aircraft Co. **Arthur G. Metcalfe,** former supervisor of physical metallurgy, Armour Research Foundation, has been named assistant director of research, while **Morris Lebovits,** former aerodynamics chief at Northrop Radioplane Div., becomes section chief, aerodynamics.

David Altman has been elected a vice-president of United Research Corp. **Joseph Yamron,** former section head, flight control systems group at MIT's Instrumentation Lab, becomes project engineer in charge of flight control systems, Hamilton Standard Div.

Edwin G. Schneider, former chief engineer, Sylvania Electronic Systems Div., has been named vice-president of research and engineering. New general managers for divisional operations are **Richard M. Osgood,** for Waltham (Mass.) Labs; **H. C. Tittle,** for Buffalo (N.Y.) operations; and **E. J. Vigneron,** for Data Systems Operations, Needham, Mass.

William A. Mussen, former chairman of Southwest Research Institute's Electrical Engineering Dept., has been named chief development engineer for the Singer-Bridgeport facility of Singer Military Products Div.

Franz Fischer, former principal engineer in the Research Dept. of Bulova Research and Development Labs, has joined the Aircraft Equipment Div. of Consolidated Diesel Electric Corp. as a staff scientist.

Brig. Gen. Joseph A. Bulger (AF-Ret.), has joined Sperry Gyroscope Co. as director of plans and systems, Countermeasures Div. **William F. Horn** has been appointed manager of field operations in California, Nevada, Utah, Arizona, Colorado, and Wyoming.

Arthur Ash has joined Spacelabs, Inc., in an executive capacity.

Donald W. Smith has been elected president of General Precision Equipment Corp. He formerly was president of Kearfott Co., Inc., a subsidiary, where he is currently board chairman. **Fred D. Herbert Jr.** has been elected president of Kearfott Co.

T. P. Cheatham has been named manager of the new Applied Science Div. of Melpar, Inc., and **Robert Snow,** assistant manager. **David Van Meter** and **Glenn Fellows** will head the Research and Advanced Design departments, respectively. **John Gerdes** becomes manager of research project coordination. In the Advanced Design Dept., **Fred Benkley** has been promoted to manager of engineering project coordination; **Alvan S. Berner,** to head of systems design; **Theodore C. Randall,** to head of circuit design; **Frank G. Usseglio,** to head of mechanical design; and **Lawrence W. Gay,** to head of all support services.

Peter L. Nichols heads the new propulsion group recently formed within Stanford Research Institute's Poulter Labs, while **Raffaele F. Muraca** will direct work in chemistry and physics, and **Thor L. Smith,** undertakes propellant research and development.

Gordon S. Burroughs has been appointed vice-president of CBS Labs, in charge of the newly expanded Military and Industrial Electronic Systems Dept. **Alfred E. Kaspaul** has been made technical manager of the Solid State Physics Labs, and **Nicholas Fuschillo** joins the company as head of its Solid State Physics Dept.

Rear Adm. Caleb B. Laning (USN-Ret.), has been named assistant to the president of Stavid Engineering, Inc.

Maj. Gen. T. C. Odom (AF-Ret.) has been appointed director of systems management for IBM's Military Products Div. **J. A. Haddad** and **Bryon L. Havens** have been named general manager and technical director in charge of all engineering and technical activities, respectively, of the newly formed Advanced Systems Development Div.

Frank A. Parker, former director, technical development, American Radiator and Standard Sanitary Corp., has moved to the Defense Dept. as assistant director, defense research and engineering for undersea warfare. **Bruce H. Billings,** vice-president and director of Baird-Atomic, Inc., will serve as assistant director of research and engineering, in charge of special projects.

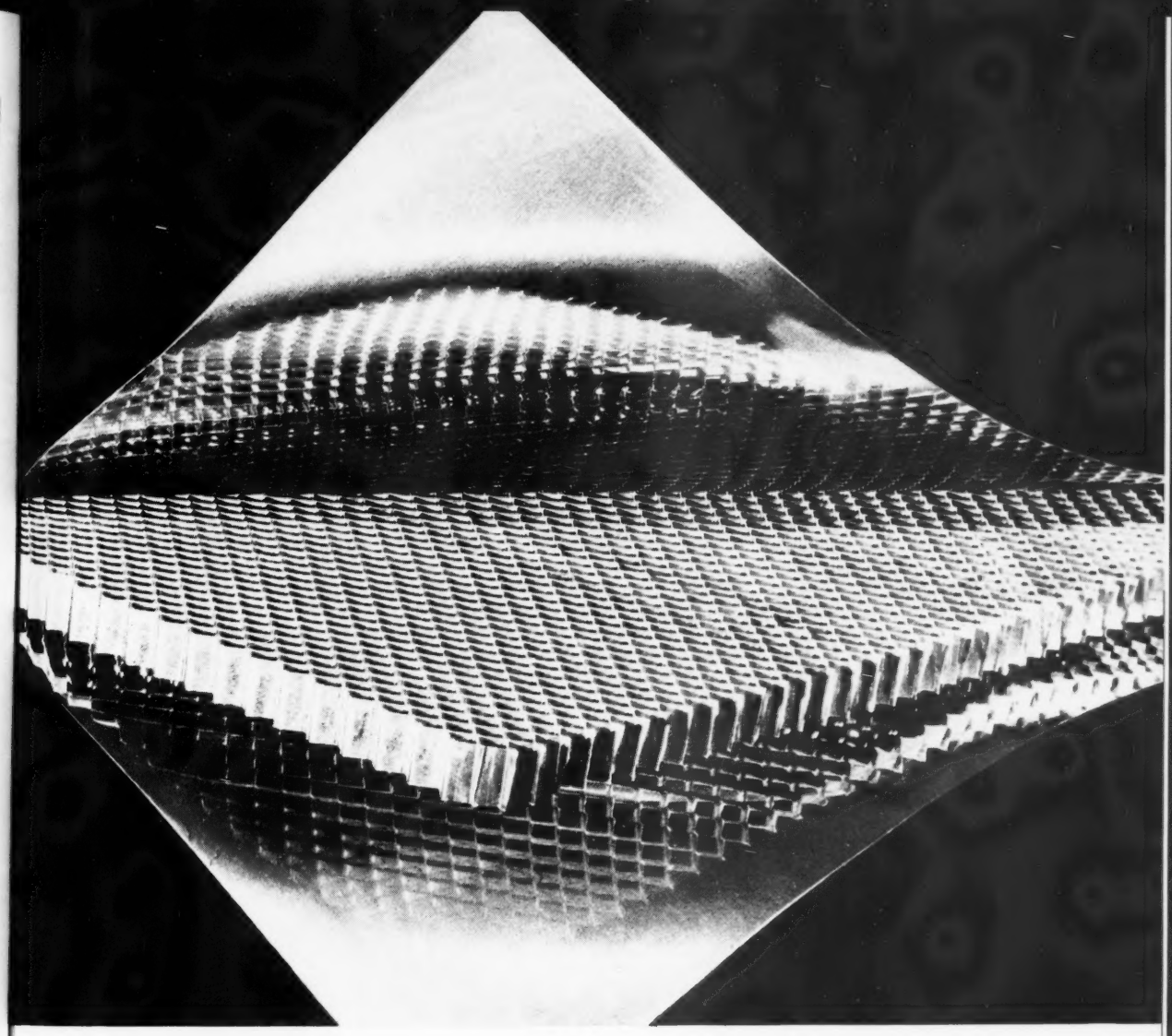
HONORS

Herbert Friedman, Superintendent of NRL Atmosphere and Astrophysics Div., has received the Defense Dept.'s Distinguished Civilian Service Award "for development of radiation detection devices and conduct of important research in astronomy and astrophysics, including the first ultraviolet rocket survey of the celestial sphere."

S. K. Hoffman, general manager of Rocketdyne Div. of North American Aviation was presented with the Robert H. Goddard Memorial Trophy at the National Missile Industry Conference for "his outstanding individual contribution to astronautics during 1958."

Karel J. Bossart, assistant to the vice-president-engineering for Convair Div. of General Dynamics Corp., has been named "Man of the Year in Science" by the California Air Force Assn.

Harvey D. Palmer, Hughes Aircraft engineer, has been awarded an AF citation for meritorious service and significant contribution to the Air Defense Systems Integration Div. at Hanscom Field, Bedford, Mass. **Theodore G. Macklin,** manager of field engineering in the Hughes Field Service and Support Div., Culver City, and **Merle Holpert,** Hughes manager of services and head of outside production at the Tucson plant, have been awarded Alfred P. Sloan Foundation Fellowships to attend a one-year course in executive development at MIT's school of industrial management.



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World's Most Beautiful Rocket Test Area?

Japanese TLRM-1D ground-to-air rocket soars aloft from what may well be the world's most beautiful test area—the firing range maintained by the Japanese Self-Defense Board's Technical Research Lab near the North slope of Mt. Fuji. The liquid-fuel rocket, built by Mitsubishi-Nagasaki and using a booster made by Fuji Seimitsu, is 3.3 m long, weighs 253 kg, and attained a speed of 115 m/sec in the test.

Positive Ions in the Ionosphere

(CONTINUED FROM PAGE 31)

axis—are enclosed in a vacuum-tight stainless-steel envelope, the left end of which is mounted on the skin of the rocket and is open to the surrounding atmosphere. As the rocket travels up through the ionosphere, ambient positive ions diffuse into the tube through the first grid, which is electrically grounded to the rocket skin. The second grid is connected to a negative voltage (V_A) which produces an accelerating field in the region between the first and second grids. A positive ion of mass m and charge e will accelerate toward the right and by the time it crosses the second grid will have attained a velocity v determined by the energy equation $^1/_2\ mv^2 = eV_A$. By the proper setting of V_A, an ion of any given e/m ratio can be made to attain a certain fixed velocity v_o for which the tube was designed.

The following grids form the analyzer, which allows only those ions having velocity v_o to reach the collector at the far right end of the tube. Examination of the above equation, assuming fixed v_o and singly charged ions, reveals that the singly charged ion of mass m that is allowed to traverse the tube is directly proportional to V_A, or $m = 2e/v_o^2\ V_A$. This means that if V_A is slowly varied in a sawtooth manner, then the value of m, which is analyzed at any instant, is linear in the same way.

The velocity filter, which passes only those ions having velocity v_o, is composed of three sets of three grids (grids "2" through "10") separated by two drift spaces. The outer grids of each triplet are all electrically connected together to V_A. The center grids of the triplets are also connected together and via a resistance (R) to V_A. Impressed across this resistance is an RF sine wave voltage ($V_{RF} \ll V_A$).

Grids Are Tied to V_A

Thus all grids are tied to V_A DC-wise, but the center grids of each set have a little RF added to their instantaneous DC level. Ions traversing the first triplet are subject to the RF field while between grids "2" and "4". The RF frequency and grid spacings are so chosen that, if the ion with velocity v_o crosses the center grid at 180 deg RF phase angle, a maximum impulse of energy is imparted to the ion. Because ions drift into the tube at random, some of the ions having velocity v_o enter at nearly the required phase angle. Those which enter with the wrong velocity or phase will gain less than the maximum energy or may even lose energy. The selected ion, having gained incremental energy Δw, enters the first drift space, the length of which is such that an ion traveling with speed v_o traverses the distance between center grids in exactly an integral number of RF cycles. If the ion enters the first triplet with the proper phase and velocity, it will automatically do the same in the second triplet, and once again in the third. This selected ion leaves the last triplet with a $3\Delta w$ excess of energy over that with which it entered the tube.

In order to reach the collector and so register a successful passage, the ion must pass through a barrier grid which is set at a positive DC voltage slightly lower than $3\Delta w$ volts. Those ions which have gained close to the maximum incremental energy will cross this voltage barrier, while those which entered the analyzer with the wrong velocity or phase will approach the barrier with insufficient energy to cross. Ions which cross the barrier are neutralized at the collector, and the amplitude of electron current is telemetered to the ground recorders.

For the rocket experiment, V_A was a linear $1^3/_8$-sec sawtooth sweep voltage generated by a motor-driven potentiometer. Two typical positive-ion spectra recorded at ground stations when the rocket was at an altitude of approximately 167 km are shown on page 31. The significance of the "harmonic" peaks will be explained later.

The operation of the negative-ion mass spectrometer is almost identical to that of the positive ion, only all the DC grid voltage polarities are reversed. The neutral-gas spectrometer uses a beam of electrons through which the entering atmospheric gas must pass before entering the analyzer section. Those particles which are ionized by this electron beam can then be analyzed. This spectrometer, enclosed in a glass envelope, is vacuum sealed to prevent its contamination before flight. The tube is mounted just below the tip of the rocket. The ejection of the tip at approximately 100 km opens the tube to permit entry of gas and its subsequent analysis.

The photo on page 31 is of the instrumentation installed on an Aerobee-Hi rocket prior to flight at Fort Churchill, Canada, and shows the relative placement of the spectrometers. The arrow points to the positive-ion spectrometer opening, which is protected by a dust cover. The negative-ion tube points out the other side of the rocket. The hardware section comes next and contains the telemeter, the radar transponder, batteries, and power-control relays. The tapered section contains all the electronics for the three mass spectrometers. The neutral-gas spectrometer is mounted

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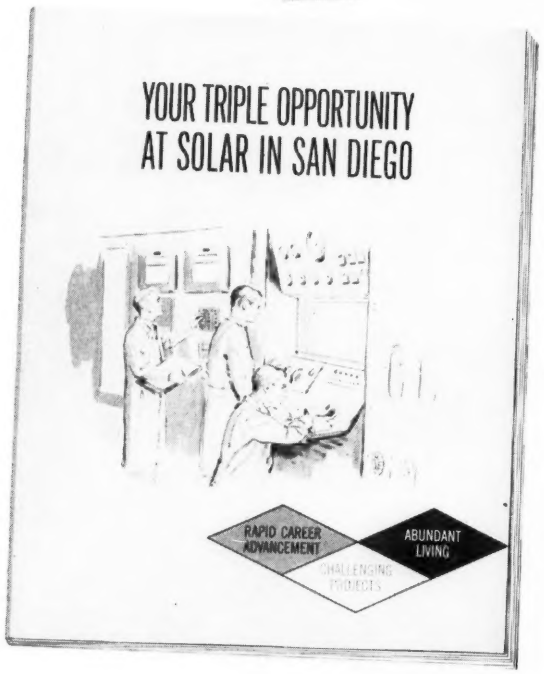

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on top of the electronics. A nose cone, of course, covers the equipment. Four Aerobee-Hi ion-composition rockets were flown during the IGY from Fort Churchill.

Because the mass spectrometers analyze matter present in the immediate vicinity of the rocket, it is necessary to vacuum-seal the rocket to prevent contamination. In the Aerobee-Hi design, vacuum-sealing is accomplished by the extensive use of O-ring gaskets at all joints and openings in the rocket skin in both the nose and tail sections. Finally, after burnout, pyrotechnic shutoff valves seal the propellant tanks.

We now come to the bypassed topic of "harmonics." Because a rocket sometimes acquires a negative charge in its passage through the ionosphere, the thermal ionospheric positive ions entering the spectrometer will have a net energy equal to the voltage V_r of the rocket. For such an ion to acquire the proper velocity v_o, V_A will have to be reduced by V_r volts. Thus, the value of V_A corresponding to a given mass m will be unknown in the absence of a measurement of V_r. The V_A-versus-mass relationship becomes $m = 2e/v_o^2\ (V_A + V_r)$, and a given m can no longer be identified with a known V_A.

This problem was solved with the aid of a new technique which used a heretofore unappreciated feature of the Bennett spectrometer. Fortunately, there are certain fixed "harmonic" velocities other than v_o with which an ion can traverse the spectrometer and gain energy. This energy gain is always less than $3\Delta w$. But, by setting the barrier grid potential well below the $3\Delta w$ level, these harmonic ions can register. The top spectrum of the two shown on page 31 was obtained under this lowered barrier grid condition. Thus, ions are purposely allowed to traverse the spectrometer for two different values of V_A. The important feature of this mechanism is that the V_A difference between a fundamental (v_o) ion peak and its associated harmonic is always proportional to the true mass of the ion being analyzed ($V_{A_{\text{fundamental}}} - V_{A_{\text{harmonic}}} = K_1 \cdot m$). If, in addition, V_r is eliminated, we can write the differential mass scale equation for fundamental peaks as follows: $\Delta m = K_2 \cdot \Delta V_A$. The mass-to-$V_A$ proportionality factor K_2 is a constant, the value of which is fixed by the spectrometer dimensions and the crystal-controlled RF frequency. Calibration of the spectrometer consists of accurately measuring K_2.

If, as is the case of the top spectrum shown on page 31, there appear at least two fundamental ion peaks and their respective harmonics, an expression for the mass of the lighter ion

(m_x) can be written in terms of the mass difference (Δm_{xy}) between m_x and the heavier m_y, and the apparent mass differences between the fundamentals and their respective harmonics Δm_x and Δm_y, in this manner:

$$m_x = \frac{\Delta m_{xy} \cdot \Delta m_y}{\Delta m_y - \Delta m_x}$$

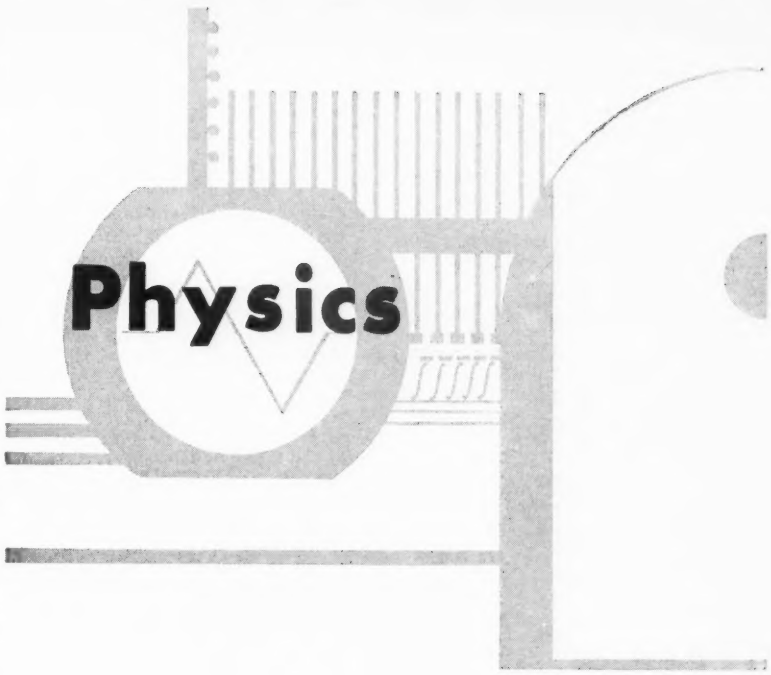
During a rocket flight, fundamental peaks are distinguished from harmonics by varying the barrier potential. The lower spectrum of the two appearing on page 31 shows only fundamental peaks. The required mass differences for the last equation were obtained from the spectra, and the absolute mass scale was determined as shown. Six positive ions have been identified on the four flights: Masses 32^+, 30^+, 28^+, 18^+, 16^+, and 14^+ AMU. Of these six, masses 32^+, 30^+, and 16^+ dominate the spectra.

The graphs on page 31 show spectral peak amplitudes versus altitude for the first three Aerobee-Hi flights. The curves are based on a partial analysis of the flight data, and as such give the gross picture rather than the fine details of the final analysis. The relative abundance of an ion at a particular altitude is represented by the horizontal width of the area assigned to each ion, the total of all three adding up to 100 per cent.

For example, mass 30^+ (nitric oxide) dominates the region below 200 km at night. Mass 32^+ (molecular oxygen), although abundant below 100 km during the daytime polar blackout, is only a minor constituent of the lower E-region during the night. Starting in the 130-km region, Mass 16^+ (atomic oxygen) appears on all flights, and above 200 km it becomes the predominant ion.

The surprising and totally unpredicted feature of these distributions is the large amount of mass 30^+, which is presumed to be nitric oxide. To date there has been no direct measurement of its neutral abundance. Its discovery as the major constituent in the E-region permits a clearer interpretation of its formation and retention. There are several ion-chemical charge exchange reactions responsible for the formation of NO^+. An example is the reaction between atomic oxygen ions and neutral molecular nitrogen: $O^+ + N_2 \rightarrow NO^+ + N$.

To complete the positive-ion investigation, a special Bennett spectrometer was built to detect atomic and molecular hydrogen ions. This unit was flown in the fourth rocket of the series. The results were negative, indicating that the density of ionized hydrogen is less than 10^3 per cubic centimeter in the first 100 km of the ionosphere.



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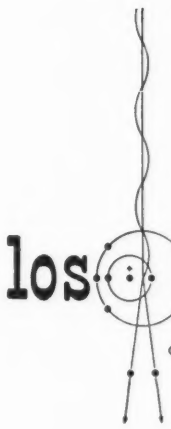

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Government contract awards

NASA Names Convair Vega Prime Contractor

In a $33.5 million contract, NASA has named Convair-Astronautics prime contractor for Vega. The Convair contract calls for eight vehicles by the end of 1961.

Callery Chemical Gets Rocket Propellant Study

Evaluation of a new and classified rocket propellant, which would permit substantial increases in payload weight and would be noncryogenic, will be undertaken by Callery Chemical under a $175,000 NASA contract. Reaction Motors will be a major subcontractor.

High-Altitude Rocket System Developed for ARDC

A 29-lb rocket system, tagged Owl, which provides meteorological soundings at altitudes as high as 240,000 ft, has been developed by BJ Electronics, Borg-Warner Corp., under an ARDC contract supervised by AFCRC. Currently being successfully operated at Holloman AFB, the system utilizes a solid-propellant rocket of 3.0 in. diam to propel a small ballistic dart carrying a timing device which ejects radar reflective payloads at desired altitudes.

Republic Awarded ICBM Defense Job

Republic Aviation's Missile Systems Div. has received contracts in excess of $300,000 for R&D of highly sophisticated ballistic missile defense systems—centering around decoy discrimination and target destruction—from Air Force's Special Weapons Center, ARPA, and WADC.

$11 Million Thiokol Pact

An $11.9 million continuation contract for production of rocket motors and plant maintenance at the Longhorn Ordnance Works, Marshall, Tex., has been awarded to Thiokol Chemical by the Army Ordnance Ammunition Command, Joliet, Ill.

Nike-Zeus R&D

ARGMA has issued a $8,671,100 contract to Western Electric to supplement R&D efforts for the Nike-Zeus anti-missile missile system.

Advanced Solid Propellant

Army Ordnance has awarded a contract for about $500,000 to the Energy Div. of Olin Mathieson Chemical Corp. to explore uses of an advanced solid propellant for the Nike-Zeus.

Pogo-Hi Contract

Aeronca Mfg. Corp. has received a production contract for Pogo-Hi II E3C target missile systems for the White Sands Missile Range, with initial quantity to be delivered within 60 days.

36-In. Balloon Telescope

In continuation of Project Stratoscope, Princeton Univ. has awarded Perkin-Elmer Corp. $940,000 in contracts for design and construction of a 36-in. aperture telescope to be carried to high altitude by unmanned balloon for photography of the planets and celestial bodies.

Drone Guidance System

Minneapolis-Honeywell Regulator Co. received a multi-million dollar contract from Fairchild Engine and Airplane Corp. for development of a new miniaturized inertial guidance system for navigating a new Army reconnaissance drone (AN/USD-5).

Rocket Engine Cases

Budd Co. has been awarded a contract by Thiokol Chemical for construction of solid-propellant rocket engine cases with a new alloy steel for the Minuteman ICBM.

NASA CONTRACTS FOR APRIL

Contractor	Obligation	Program
Douglas Aircraft	$24,000,000	Thor-Delta, three-stage launching vehicle.
Univ. of Maryland	$ 60,000	Investigation of forces between atoms, molecules, and ions.
Rice Institute	$ 110,000	Studies of performance and flow in test section of maximum Mach number wind tunnels.
Rice Institute	$ 50,000	Research into physics of solid materials at high temperatures.
Rensselaer Polytechnic Institute	$ 80,000	Mathematical investigation of a variety of control systems.
Univ. of California	$ 120,000	Study development of and chemical reactions occurring in a gaseous detonation wave.
Itex Corp.	$ 170,000	Develop sounding rocket instrumentation to sample upper atmosphere.
New York Univ.	$ 100,000	Instrument two Aerobee-Hi rockets for neutron intensity measurements.
AOMC	$ 150,000	Radiation satellite payload.
MIT	$ 50,000	Develop atomic clock using cesium vapor for a satellite.
MIT	$ 70,000	Gamma ray detection instruments and a prototype for a satellite.
Univ. of Minnesota	$ 70,000	Construction of radiation detection instruments for a satellite and a space probe.
Univ. of Michigan	$ 80,000	Satellite instrumentation for measuring intensity of radio noise levels above the ionosphere.
Univ. of Michigan	$ 80,000	Satellite instrumentation for measuring ultraviolet solar emission spectrum.
Univ. of North Carolina	$ 60,000	Design and build a directional counter system to investigate primary cosmic radiation for a satellite.
Univ. of Chicago	$ 300,000	Build cosmic ray measuring instrumentation for a space probe.
Butler Aviation	$ 150,000	Modification of Government airplanes used by NASA.
General Mills	$ 60,000	Furnish nine 100-ft-diam plastic balloons for communication satellite tests.
Aeronutronics Systems	$ 90,000	Studies for Project Mercury tracking network.
RCA Service Co.	$ 60,000	Planning studies for ground tracking and instrumentation facilities for Project Mercury.
American Potash & Chemical	$ 50,000	For 161,000 lb of ammonium perchlorate for solid-propellant research at NASA's Langley Research Center, Langley Field, Va.
Chance-Vought Aircraft	$ 950,000	For four-stage Project Scout integration and a launcher.
General Electric	$ 50,000	Furnish two telemetry and beacon antenna systems for Project Mercury.
Cincinnati Testing & Research Laboratory	$ 80,000	Tests on Project Mercury capsule heat shield.
AF Air Materiel Command	$ 120,000	Five pressure suits for use in Project Mercury tests.

Mercury Tape Recorders

Consolidated Electrodynamics Datalab Div. will design and develop airborne magnetic-tape recorders for Project Mercury under a $135,480 contract from McDonnell Aircraft.

Mercury Radar Units

Avion Div. of ACF Industries has been awarded a $434,805 contract by Collins Radio Co. for Project Mercury radar beacons for precision tracking.

Data Acquisition System

A data-acquisition system that will be used to monitor and record information in tests of solid-fuel rocket motors and process the data for analysis will be built by Minneapolis-Honeywell Regulator Co. under contract to the Navy's Allegany Ballistics Lab.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

ARMY

New York Ordnance Dist., U.S. Army, 770 Broadway, New York 3, N.Y.

Basic research entitled Performance Comparison of Various Systems of Satellite Re-Entry, $70,000, **Brooklyn Polytechnic,** 333 Jay St., Brooklyn 1, N.Y.

Basic research entitled Atom Beam Scattering Studies, $27,000, **New York Univ.,** Washington Square, New York 3, N.Y.

Supporting research on high-energy oxidizers for advanced solid propellants, $723,000, **General Chemical Div. of Allied Chemical Corp.,** 40 Rector St., New York 6, N.Y.

R&D program with respect to high-energy fuels for use in advanced solid propellants, $516,625, **Olin Mathieson Chemical Corp.,** Energy Div., P.O. Box 438, Niagara Falls, N.Y.

R&D of Nike-Zeus (Nike II) guided missile system, $8,671,100, **Western Electric Co.,** 120 Broadway, New York 5, N.Y.

AIR FORCE

AF Cambridge Research Center, Laurence G. Hanscom Field, Bedford, Mass.

Research and services directed toward measurement of background radiation by balloon-borne spectrometers, $94,762, **Ball Bros. Research Corp.,** Box 191, Boulder, Colo.

Rocket techniques for studying upper air electron densities and propagation conditions, $236,000, **Univ. of Maryland,** College Park, Md.

Research directed toward the study of objective analysis of meteorological data by automatic data processing methods, $29,770, **Stanford Research Institute,** Menlo Park, Calif.

Research in micro-flipflops, $197,960, **Philco Corp.,** 4700 Wissahickon Ave., Philadelphia, Pa.

Study of low-density gas plasmas, $77,759, **Sperry Rand Co.,** Sperry Gyroscope Co. Div., Great Neck, Long Island, N.Y.

AF Office of Scientific Research, Director of Procurement, Washington 25, D.C.

Research on properties of ions in flames, $39,010, **Experiment Inc.,** Richmond 2, Va.

Research on high pressure plasma production techniques, $43,820, **Atlantic Research Corp.,** 901 N. Columbus St., Alexandria, Va.

Continuation of basic research in microwave electronics, $100,000, **Univ. of Calif.,** Berkeley 4, Calif.

Continuation of research on experimental program for ion propulsion research, $97,200, **North American Aviation,** Rocketdyne Div., 6633 Canoga Avenue, Canoga Park, Calif.

Continuation of research on phenomena surrounding high-speed flight, $232,689, **Univ. of Maryland,** College Park, Md.

Continuation of research on problems of gas dynamics on cosmic scales, $40,009, **Univ. of Rochester,** Rochester, N.Y.

Research in physics and chemistry of gases at high temperatures, $57,910, **Columbia Univ.,** New York, N.Y.

AMC Aeronautical Systems Center, USAF, Wright-Patterson AFB, Ohio.

Aerial target drones; launch rail adapters; and test equipment for the GAR-8 missile, $470,000, **Curtiss-Wright Corp.,** Santa Barbara Div., Santa Barbara, Calif.

Induction heating process for titanium, $216,527, **Mallory-Sharon Metals Corp.,** Niles, Ohio.

Sacramento Air Materiel Area, USAF, McClellan AFB, Calif.

Engineering prototype installation of an upward ejection system for F-104 type aircraft, $31,653, **Lockheed Aircraft Corp.,** P.O. Box 551, Burbank, Calif.

NAVY

Boston Naval Shipyard, Boston 29, Mass.

Necessary services, labor, and material to fabricate and test one complete warhead handling system (prototype) for Talos missile system, $292,431, **Loewy-Hydropress Div. of Baldwin-Lima-Hamilton Corp.,** 111 Fifth Ave., New York, N.Y.

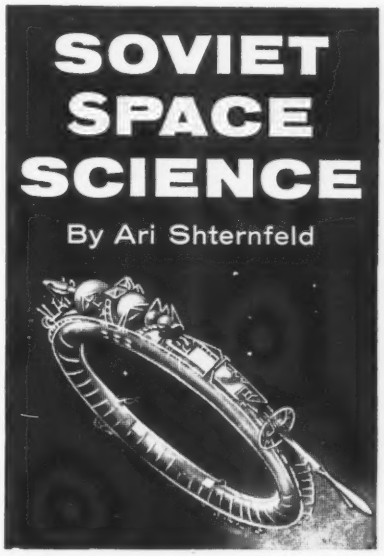
Bureau of Aeronautics, Washington 25, D.C.

Rocket pod firing devices, expendable contact fingers, $27,240, **Seaboard Electric Products Corp.,** New York 13, N.Y.

Bureau of Ordnance, Washington, D.C.

Guided missile telemetering antennas, $87,093, **Aircraft Armaments, Inc.,** Cockeysville, Md.

The Russians' Own Story of Artificial Satellites



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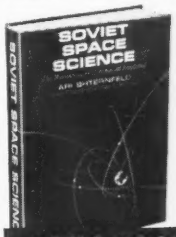

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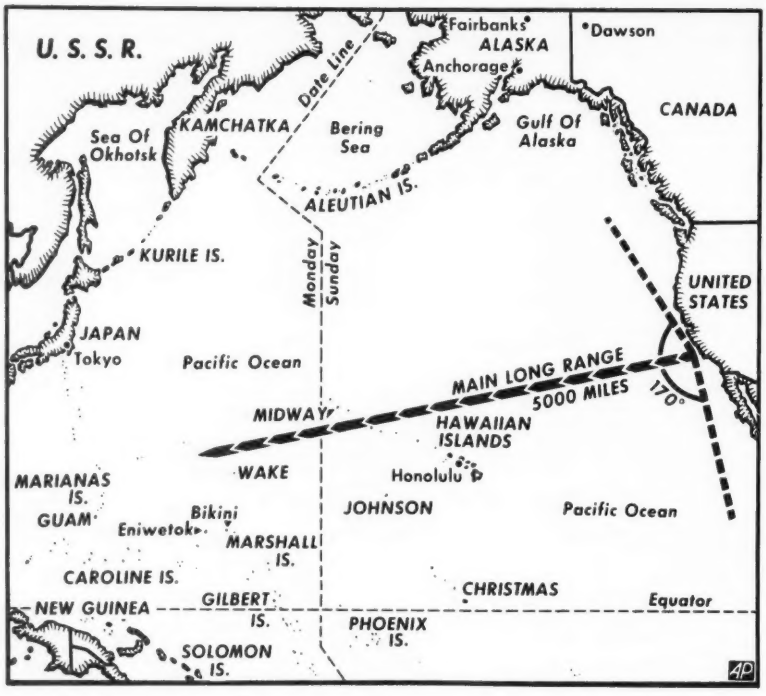

Vandenberg Missile Range

Map outlines new missile test range recently activated at Vandenberg AFB. Heavy arrows trace main shooting range of some 5000 miles; dashed lines extending northwest and southeast indicate short range firings.

Density and Temperature

(CONTINUED FROM PAGE 25)

Observatory that the apparently random fluctuations in density are actually proportional to the changes in the intensity of the 10-cm radiation from the sun, which constitutes an excellent measure of solar surface activity. Furthermore, the fluctuations show a tendency to repeat every 27 days, which is the period of rotation of the sun about its axis. Thus it apears that, in addition to the heating and expansion of the atmosphere produced by steady solar exposure, there is further heating caused by streams coming from definite spots on the surface of the sun that appear and disappear every 27 days in the course of its rotation.

The satellite results do not show the strong latitude dependence which appears in the rocket data. Satellite measurements always give the density at the position of perigee, and a satellite therefore automatically samples a broad range of latitudes during the course of the rotation of its perigee in the plane of the orbit. With Vanguard I, for example, the latitude of perigee changes from 33 deg North to 33 deg South every 41 days. Although Vanguard I has been transmitting signals for more than a year, the tracking data have shown no significant changes thus far which can be correlated with latitude variations. The contrast between this result and the major latitude dependence in rocket data constitutes an outstanding puzzle in the interpretation of the IGY data.

As so often happens in research, the attempt to resolve this difficulty leads us to some of the most interesting implications in the IGY density data.

The particles in the Van Allen belt may provide the explanation for the difference between atmospheric properties in the Temperate and Arctic Zones. The Van Allen particles are trapped by the earth's magnetic field in orbits, in which they spiral along the lines of magnetic force. As the figure on page 24 indicates, the particles in the outer belt are funneled into the Arctic and Antarctic zones by the concentration of the magnetic field near the North and South Poles. The outer belt dips down into the atmosphere in these regions and disturbs the normal conditions which exist at other latitudes.

The interaction between the trapped particles and the atmosphere has two major consequences. First, we are rather certain that the aurora borealis and the aurora australis result from the excitation of the arctic and antarctic atmospheres by collisions between the air atoms and the particles trapped in the outer zone. Second, the temperature of the auroral zone will be raised by the energy transferred in collisions between the trapped particles in the outer belt and the atoms and molecules of the upper atmosphere.

Heating Theories

Theories on heating of the upper atmosphere by channeling of charged particles in the earth's magnetic field predate the discovery of the Van Allen belt. However, the Van Allen data, supplemented by Sputnik III results and by rocket measurements performed by NRL and SUI, provide an opportunity for the theorist to make a quantitative test of this interesting suggestion.

To make the necessary calculations, we construct an idealized model in which the heating effect of the Van Allen layer is confined to a definite region in the auroral zone, whose boundaries are kept at a "temperate" level of 1000 K. The rate of heat transfer to the air within this zone is calculated from the combined rocket and satellite observations on Van Allen particles.

The figures on page 24 describe the Van Allen belt, the region (boxed area) for constructing the idealized model, and a schematization of the model auroral zone in the boxed area.

The equation of heat conduction may be solved analytically with the indicated boundary conditions. I. Harris and the author have shown in this way that the temperature must rise to approximately 2500 K at the center of the auroral zone. The close agreement of our calculations with observation is fortuitous in view of the approximations made in boundary values. However, it is significant that the temperature increase has the correct order of magnitude. (Additional calculations have been undertaken with a more realistic model.)

This analysis leads us to a picture of the upper atmosphere in which densities in the auroral zone are controlled by the Van Allen layer, while densities outside the auroral zone are relatively independent of latitude. If this picture is correct, we must consider two distinct models of the atmosphere.

The first model, which may be called the Temperate-Equatorial At-

mosphere, is represented by Curve T-E of the graph on page 25. It is obtained by drawing a smooth curve through the White Sands' rocket data and the data obtained from Explorer I and Vanguard I. All density data used in the construction of this model were obtained at latitudes no greater than 33 deg.

The second model is the auroral atmosphere shown as Curve A of the graph on page 25. The auroral atmosphere consists of the rocket observations at Fort Churchill extrapolated above 200 km with the assumption of a constant temperature. The assumption of constant temperature is based on the LaGow measurements, which indicate little temperature variation between 170 and 210 km.

It is interesting to note that on the basis of the T-E model the oxygen atmosphere will give way to a hydrogen atmosphere at an altitude of approximately 1200 km.

Suggested Additional Reading

Analysis of Temperature, Pressure, and Density of the Atmosphere to Extreme Altitude, G. Grimminger, Rand Report R-105 (1948).

Pressures, Densities, and Temperatures in the Upper Atmosphere, Rocket Panel, Phys. Rev., *88*, 1027 (1952).

Physical Properties of the Atmosphere from 90 to 300 Kilometers, H. K. Kallmann, W. B. White, and H. E. Newell, Journal of Geophysical Research, *61*, 513 (1956).

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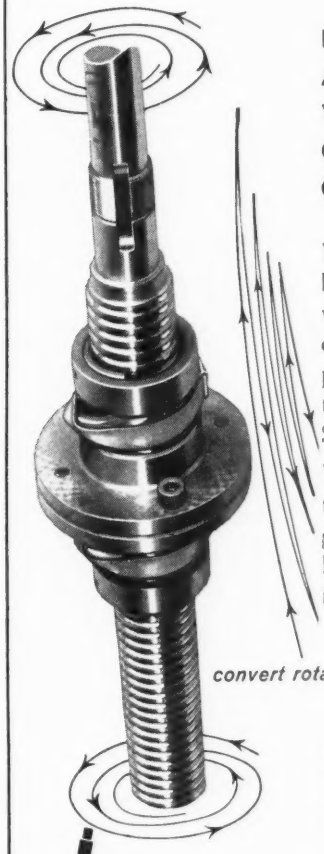

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International scene

BY ANDREW G. HALEY

The astronaut abroad in Europe certainly will not be surprised upon finding very extensive research and development work being accomplished in the United Kingdom, Italy, France, Spain, and the Scandinavian countries, and indeed in Eastern European countries such as Poland, Czechoslovakia, and Yugoslavia. Russia, of course, is a world unto itself. During my current visits to all these countries, I was surprised how much greater the astronautical effort is than we, in America, realize. My greatest surprises occurred during my visit with the South African Interplanetary Society in Johannesburg and in sorties to other South African cities.

After all, I should not have been surprised, for South Africa is the home of Prof. A. E. H. Bleksley, president of the South African Interplanetary Society and world-renowned professor of applied mathematics at the Univ. of Witwatersrand; F. J. Hewitt, director of the National Institute for Telecommunications Research; and A. Blainey, C. B. Jeppe, K. Howell, R. Heuberger, H. Th. van den Ham (technical director of the SAIS), J. A. McMorran, A. W. Andersen, and many other scientists and engineers of outstanding ability. These men have been a source of inspiration and support for the great young generation of rocket experimenters and engineers.

One example is typical of the work being done in South Africa. For the past four years, the Port Elizabeth branch of the SAIS has been conducting tests on rocket motors at its branch headquarters in that city, on the east coast of the Union of South Africa.

The leader of this team of young experimenters was Alan Bowman, who left earlier this year to take up an appointment at the Royal Aircraft Establishment, Farnborough, England. He was assisted by John Deschamps, also of Port Elizabeth.

In all, the group successfully launched about 10 solid-fuel rockets and tested liquid-fuel rockets. These tests were made with the assistance of the Union Defense Force and in the presence of observers from Rhodes Univ., Grahamstown.

In October 1958, the group fired the first two-stage rocket, which was equipped with a parachute opened by blowing the nose off the second stage of the rocket. This rocket was designed to carry instruments 17,500 ft up into the atmosphere, and was the forerunner of another rocket which the group is building with the hope of reaching an altitude of 100,000 ft.

Specifications of the October rocket were:

Over-all Length: 17.5 ft. Booster, 5.22 ft. Main stage, 12.17 ft.
Diameter: Booster, 4 in. Main stage, 2 in.
Base section, 3 in.
Diameter over fins, 2 ft.
Weight: Launching (total) 150 lb.
Payload: Up to 4 lb.
Thrust: Booster, 2000 lb for one sec.
Thrust: Main stage, 512 lb for 1.5 sec.
Velocity at booster burnout: 460 fps.
Velocity at main stage burnout: 460 fps.

Propellant: Zinc dust and sulphur.

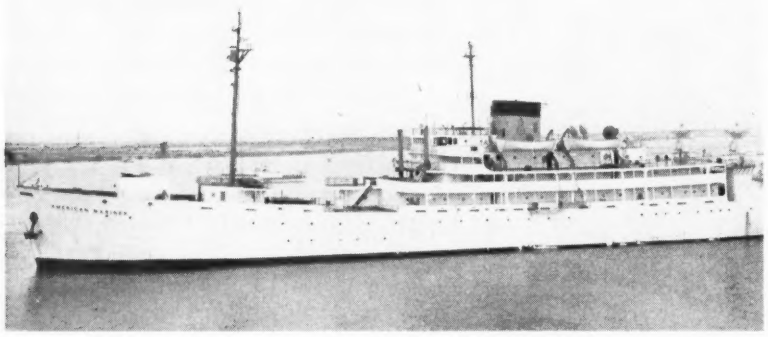
Due to an accident on takeoff, the rocket reached a height of only 4000 ft, the first stage separating from the second stage successfully. However, an explosion occurred at this height and the second stage disintegrated.

The group is also experimenting with ramjet motors and hopes soon to develop a low-cost high-altitude rocket for research purposes. Previous launchings have carried rockets to heights of 8000 ft and higher.

In Cape Town, the SAIS branch is now gathering funds to purchase a small radio telescope which it intends using for research purposes.

My visit was a prelude to a rocket symposium of general interest, including a consideration of space law and space medicine, running from May 26 through June 12, in a number of cities.

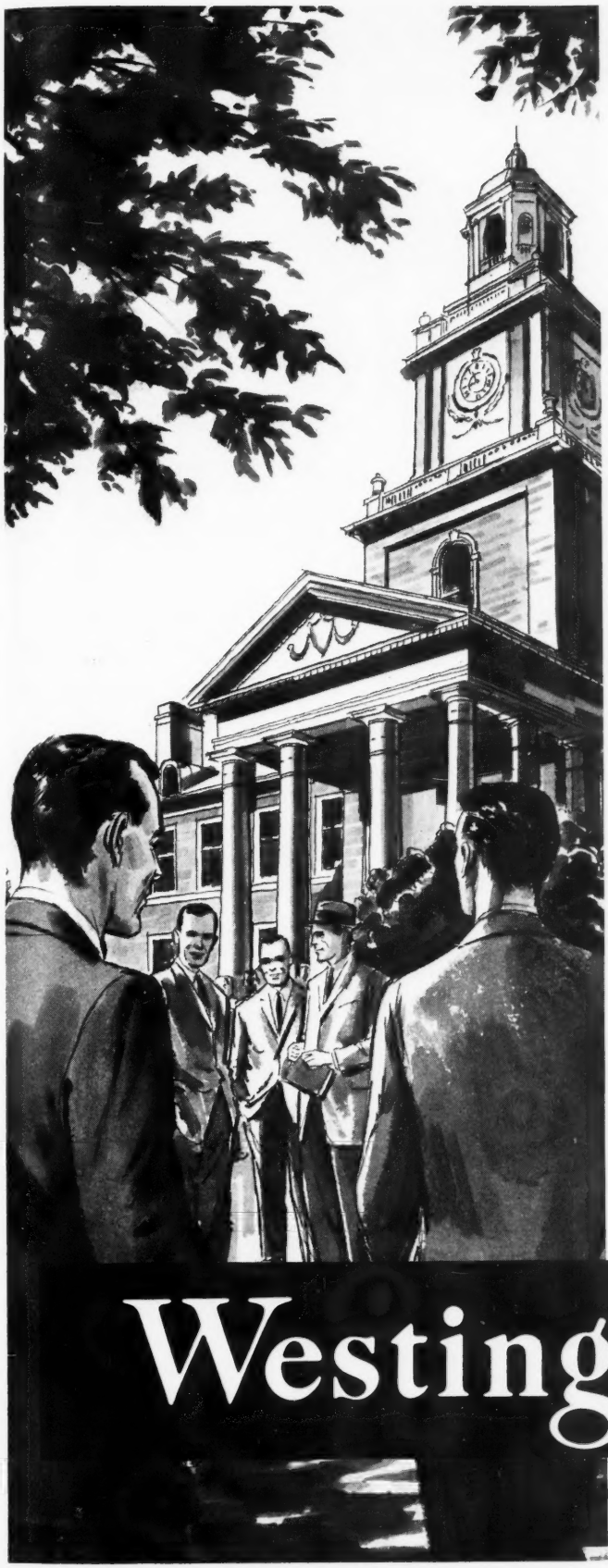
The entire symposium was organized by Roy W. Terry, the foremost science writer in South Africa, and an indefatigable worker and organizer.



Above, the American Mariner, new tracking ship for the Atlantic Missile Range, arrives at Cape Canaveral. Below, one of the large radar antennas on the Mariner.

Canaveral Missile Tracking Ship

Sponsored by ARPA for the Army Ordnance Missile Command, and contributed to by the Air Force and Navy, the American Mariner, a missile and space-vehicle tracking ship with the most advanced radar, electronic, and optical equipment, recently joined the tracking network of the Atlantic Missile Range. The services will share information it collects.



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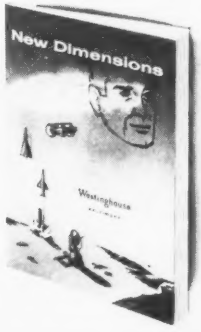

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BALTIMORE

On Portola's Ground

(CONTINUED FROM PAGE 47)

first session of the meeting, "Astronomy from a Space Platform," underscored the growing interdependence of research and engineering sciences. Astronomical research from a space platform should virtually revolutionize our perception of the solar system. Engineering science should produce an appropriate platform within five years. In one paper from this session, "Radio Astronomy Observations from Space," Fred T. Haddock of the Univ. of Michigan discussed four important studies that can be made from a space platform with simple antennas and conventional radio receivers: (1) Dynamic spectra of solar radio bursts, (2) dynamic spectra of radio bursts from Jupiter, (3) the spectrum of cosmic background radiation, and (4) distribution of electron densities outward from the F-layer. In the same session, Robert Davis of the Smithsonian Astrophysical Laboratory, outlined requirements for optical space telescopes, while James Kupperian of NASA described the national space agency's plans for an orbiting astronomical platform.

The next session, "Man to Space," turned attention to a major associated problem—the spacecrew conditioning ("holding") station in the launching area, or as the paper by Siegfried Gerathewohl put it, the problems of selection, holding, and care of space fliers. As Lt. Bruce Pinc of BMD pointed out in his paper, "The Role of the Physiologist in the Space Crew Holding Facility," this ground station will have to be tailored to the conditioning of the space pilot, and consequently will differ considerably from present aircrew support facilities. The roles of the doctor and psychologist will, he expects, be major ones in this facility, and will require "living in" by many members of the staff.

In a following session on "Man in Near Space," Edwin Vail of WADC, discussing pressure suit requirements for space vehicles, emphasized an important aspect of space programs—the great deal of engineering that must be done to produce just one key item of space equipment. As a case in point, the past several years have seen enough technical advances and engineering study to resolve major problems of pressurized spacesuit mobility and ventilation, but according to Dr. Vail the requirements for suit design still cannot be determined without more data on radiation protection.

"Logistics and Operations" followed "Man to Space," and amplified the discussion of space mission support, with emphasis on the larger operation of low-density and future rocket systems.

In general, the whole attendance enjoyed this continuity of topic and interplay of particular problems.

Sessions on ground support, sounding rockets, IGY findings important to the astronaut, and space probes (Secret) followed. Herbert Friedman's discussion of the influence of the sun's radiations on the upper atmosphere, appearing in this issue on page 20, and Warren Berning's introduction to the ionosphere, appearing on page 26, reflect the timeliness and superior quality of the general papers in the technical sessions.

The session on sounding rockets served to review the progress being made in producing cheap and efficient high-altitude rockets for weather and upper-atmosphere studies. It appears from the progress report by Lt. Cmdr. W. S. Houston of ONR that Arcas, for instance, will soon achieve its goal of becoming a practical all-purpose rocketsonde.

Roth, Prout, and Mosich of Aerojet-General, on this subject, gave design criteria for very high altitude (up to 2000 miles) sounding rockets with adequate stability margins. They anticipate that there will be a large need for sounding rocket systems for at least

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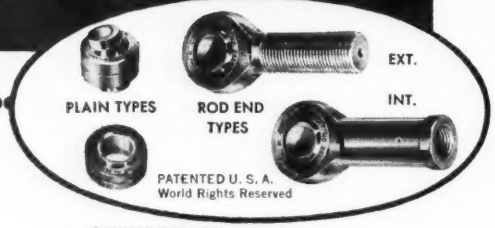

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a decade, and they expect that liquid-propellant motors will make the major contribution in meeting this need.

An outstanding session on burning processes in high-output combustors, chaired by Martin Summerfield, ought to warm the hearts of the old timers, who perhaps feel out in space at times among the nuclear and exotic propulsion enthusiasts, space communications and guidance buffs, human factors team, etc. The table on page 47 gives an example of some recent work in combustion. From the paper, "Chemical Space Heating Rates," by David Bittker and Richard Brokaw of NASA's Lewis Research Center, the table shows that several very high-energy liquid-propellant experimental motors give several orders of magnitude lower heat release rates than the theoretical maximum, and thus that future motors can perhaps be extended in performance when the limitations of engineering practicality become less severe. The theoretical and analytical papers in this session were followed appropriately by a classified session on R&D in low-pressure combustion, liquid-fluorine performance, and high-energy storable systems.

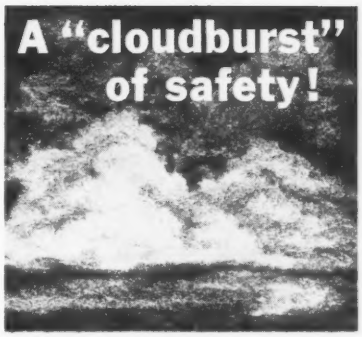
Microminiaturization Session

It was interesting to see that microminiaturization drew a whole session. Microminiaturization appears the means for a literally fantastic manipulative technology. Donal Duncan of Autonetics, in his paper "Microminiaturization for Space Applications," described some advances that can be expected. Reminiscent of Harry Kihn's comments in the May 1959 ASTRONAUTICS, Duncan said, "Even more important than any of the above approaches is the development of 'solid state circuits'. . . . Rather than calling on a circuit specialist to design (computing devices) with various electronic components now required—the decision, memory, and other circuits—a 'solid state engineer' will design in a single block of material all of these elements. This material might consist of a single thin crystal of semiconductor, with dimensions of the order of inches, modified by depositing various elements to change the lattice structure of the semiconductor surface. . . . It is possible that the depositing of thin films can be made by an automatic process and that the time to modify the crystal to a complete computer can become a matter of minutes." The hand of practicality appeared close on Duncan's exuberance, as Richard G. Schimpf of Elgin, in the paper "Data Gathering Mechanisms for Reliability Determination," pointed out that specific reliability requirements for electronics equipment are expected to be written into coming USAF specs, in particular MIL-R-25717C, which he says will call for mean-time-to-failure of 150 hr and operational life of 2000 hr.

The session of nuclear propulsion suggested an increasing discrimination among design engineers as to the most profitable avenues for exploiting nuclear energy in advanced propulsion systems. The very nice paper, "Advanced Propulsion Concepts," by Edward Fisher of Lockheed Missiles and Space Div. was an example. His analysis of proposed methods for tapping a reactor—principally the light, high-speed turbine generator and vacuum and plasma diodes—suggested that (except for some uncertainties, such as the working life of bearings) the light turbine will prove superior to diodes as an interplanetary space vehicle's electrical powerplant. Among other things, Dr. Fisher also made clear that some of the design problems of ion-propulsion systems, such as particle neutralization, did not at first receive sufficient attention. For instance, he pointed out that an electron gun kept separate from the ion gun must be roughly 1000 times longer than the ion gun, and this should prove unwieldy at the least.

Space vehicle power supplies and their application in propulsion systems received extensive attention in the following sessions on auxiliary power sources and electrical propulsion. In his paper "Interplanetary Space Probe Auxiliary Power Systems," Robert Hamilton of JPL classified and analyzed current power schemes in terms of the NASA requirements given in the table on page 47. There seems to be some debate over power systems, as Hamilton concludes that, "The solar- or reactor-powered thermionic plasma diode is very possibly the space auxiliary power system of the future."

The overtone of the 1959 Semi-Annual Meeting was great expectations of spaceflight. As felt in the informal session, the "Latest Events in Spaceflight," the tension is growing to prove the value of so much human energy being poured into space programs. Space technology does not exist by itself, but has taken on a transcendental quality of "meaning" and "purpose," has become loaded with the burden of proof that five centuries of scientific materialism will lead to more than merely machines. Astronautics may prove restricted and imponderable in any last analysis, like the checking of computer solutions for interplanetary trajectories, as described in the neat paper by Victor Szebehely of GE, but in the quest for knowledge it should not leave anyone sitting on a stone, squinting at the sun.—**J. N.**



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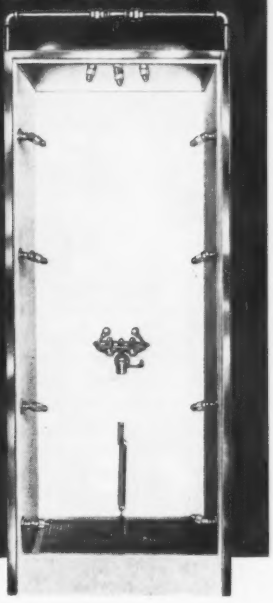

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Pioneer Radiation Instrument

(CONTINUED FROM PAGE 33)

by Dr. Van Allen, the Juno IIA radiation package was to use two identical Geiger tubes (Anton Type 302) to monitor the gross and the high-energy penetrating portion of the space radiation. This system was similar to one of the radiation packages being assembled at SUI for Explorer IV. The Geiger tube chosen for the imminent satellite and lunar experiments was tiny in comparison to the units used in Explorers before the radiation belt was established. It was hoped that reduced counting-surface area on the Explorer IV detectors would permit the tubes to operate linearly through the radiation peak if, indeed, the peak were encountered. High energy, or "hard," particles would be counted by a lead-shielded Geiger tube.

Changes in the Juno IIA radiation package circuitry, which was being designed at JPL, would be contingent only upon certain results of the yet untried Explorer IV radiation experiment. These results might have adversely affected the dynamic range of radiation expected on the lunar shot.

Explorer IV Contributed

Explorer IV results were observed a few weeks before scheduled delivery of the first Juno IIA radiation subassembly to the JPL payload group. The radiation channel containing the unshielded "302" aboard Explorer IV had saturated, with the peak nowhere in sight, and the lead in the "hard" channel reduced particle counts by only a modest 40 per cent. In view of these results, Dr. Van Allen suggested a modification of the existing Juno IIA package which would replace the "hard" detector and its associated scaler with a detector capable of measuring high-intensity radiation. The dynamic range requirements for this new detector was a subject of some concern since the peak space radiation was still a matter of conjecture.

The experiment flown aboard Pioneer III contained, as originally planned, an unshielded 302 with its attendant counters and an Anton Type 213 pulse-integrating Geiger tube followed by a stable DC amplifier. The integrating Geiger-tube was chosen in preference to the scientifically attractive ionization chamber because of its earlier availability.

As indicated in the block diagram on page 33, the radiation experiment was divided into two measurements. In one measurement, pulses obtained from the Type 302 Geiger tube processed through a trigger amplifier and then counted in a scaler, from which multiple digital outputs mixed and fed to a subcarrier oscillator. Current pulses from the Type 213 Geiger tube integrated in an R-C filter and the average voltage thus formed fed to a second subcarrier oscillator through a high-input impedance, unity voltage gain power amplifier. The resultant voltage change at the output of the amplifier or frequency shift of the subcarrier oscillator is an analogue representation of the radiation intensity. The subassembly shown on page 33 contains all the circuitry described above.

The amplifier used with the 213 Geiger tube converts average tube currents in the order of 20 to 40 microamps into output currents having magnitudes large enough to supply signal-current requirements for the associated subcarrier oscillator (300 microamps input current for full-band deflection). The transfer characteristic of the amplifier is 0.1 volt/microamps and its representative drift coefficient is 1 mv/°C at 40 C.

The high-voltage power supply for the Geiger tubes contains a transistor saturable-core oscillator which runs directly off the payload batteries and supplies square-wave power to a rectifier and voltage-doubler circuit. DC regulation is accomplished with a 700 volt Corona regulator. The regulated outputs of the supply are 730 volts and 650 volts for the 302 and 213 tubes, respectively. The high-voltage circuitry, located inside the "crown" of the subassembly, directly beneath the Geiger tubes, was foam-potted to protect it against high-altitude Corona discharge.

The circuitry connected to the shell of the 302 tube consists of an ionization-current-limiting resistor and an R-C network coupled to the trigger amplifier. The trigger amplifier standardizes pulse amplitude and coarsely regulates pulse width.

The basic flip-flop, diagramed on page 33, is a saturating transistor device capable of operation up to 100 KCPS with standard amplitude triggers. The flip-flop performs with "semistarved" collector currents (well below the normal operating level) at a power dissipation of 1.4 mw per stage. The entire chain of 17 flip-flops plus the two auxiliary stages have been demonstrated to operate reliably over wide supply voltage and ambient temperature ranges.

Output Readability

To improve the readability of the scaler output caused by a pulse input having a widely varying counting rate, three outputs were selected at four-stage intervals. These signals mix in the ratio of 1:2:4 for the first, second, and last tap, respectively. The result is the consolidation of information that might ordinarily require three subcarriers into one subcarrier. Reading speeds of slow counting rates are thereby improved by as much as 256:1 over that obtained from a single tap at the end of an identical number of counter stages.

This coding process also minimizes the number of variable speed playbacks of the telemetry magnetic tapes needed for clear, readable information. The uncompensated mixed waveform produces a large voltage step once every 217 pulses, or once every major scaler cycle. To preclude the occurrence of correspondingly large step changes in frequency at the output of the subcarrier oscillator, an auxiliary

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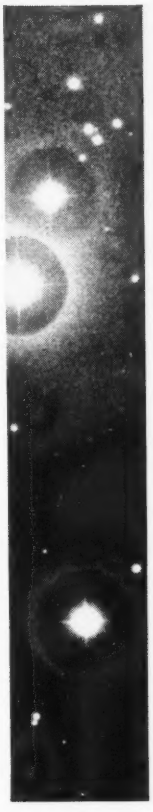
flip-flop (Stage 18 of the experiment diagram on page 33) provides step reduction at the critical point. Similar compensation is performed on the subcycle by Stage 19. The step-reduction mechanism permits minimization of the output shaping-filter time constant for given values of subcarrier band swing. The composite photo on page 32 shows actual radiation telemetry data received on the re-entry leg of the Pioneer III trajectory.

The scaler chain was made long enough to prevent the fastest expected output signal appearing at the last stage from being severely attenuated by the shaping filter in the mixing circuit. By shaping the output square-waves into exponentially rising and falling edges, steady-state signal phase error occurring in the receiver subcarrier phaselocked loop can be fixed at a tolerable maximum. In broad terms, the scaler length is indirectly determined by such interrelated items as sideband power, receiver loop-bandwidth, and signal-to-noise ratios at threshold distances.

The maximum rate at which the 302 tube will count, as determined by tube dead time or recovery time, is about 16,000 to 18,000 counts per second. When particle counting rates are far in excess of the maximum counting ability of the tube, an increasing percentage of the particles will either not be counted or will produce ionizations occurring at intervals slightly larger than the dead time. Peak-to-peak amplitude of the closely spaced pulses will be sharply attenuated, resulting in a smaller percentage of the pulses being large enough to trigger the input stage of the scaler. The reduced pulse amplitude has the effect of producing a double-valued calibration curve. This characteristic in some respects is superior to one that remains saturated, providing little or no change in scaler counting rate occurs with large changes in radiation intensity. In the region where the apparent counting rate reaches a peak and then drops off, the analog channel produces an output that still varies monotonically with radiation intensity. Therefore, the pulse integrator circuit used as a high intensity monitor can also resolve ambiguities in the 302 channel caused by the double-valued nature of its response. Maximum average count rates obtainable in Pioneers III and IV were about 12 KCPS.

Space radiation data obtained from Pioneers III and IV were monitored by JPL from Cape Canaveral, the down-range tracking station in Mayaguez, Puerto Rico, and the deep-space tracking station at Goldstone Lake near Barstow, Calif. The consequences of this experiment are now history.



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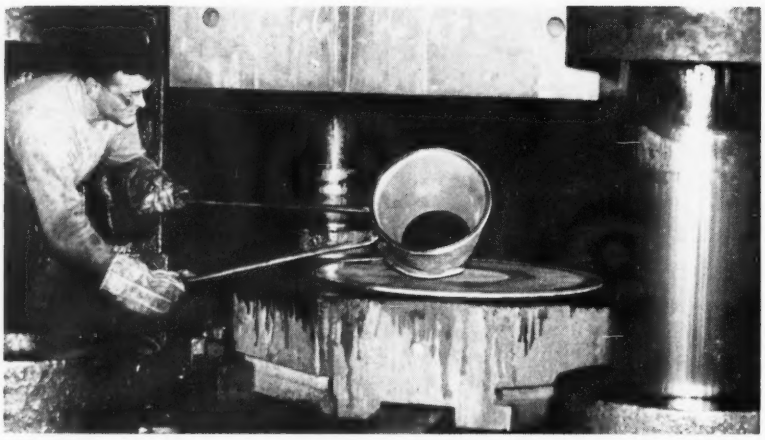

Wyman-Gordon Forges Beryllium

The conic section shown being taken from Wyman-Gordon's 18,000-ton press is the first large beryllium part die-forged in this country. The forging process, cheap and fast, greatly reduces brittleness of the metal, which otherwise has excellent structural properties, especially exceptionally high strength to weight ratio. As the price of beryllium, as yet very expensive, comes down, this exotic metal can be expected to find important uses in missiles and space vehicles, for example, in combination structural members and heat sinks.

Approach to Ionosphere

(CONTINUED FROM PAGE 27)

This was an experimental site within the zone of maximum auroral activity, where solar and magnetic influences are significant indeed. Many of the rockets launched there carried equipment for measuring electron densities in the ionosphere, total electron content, and, in two instances, ion densities and electron temperatures.

Soviet Experiments

In the U.S.S.R., a number of geophysical rockets were launched during the IGY, and some of these carried instruments to measure ionospheric properties, with emphasis placed on measurements above the altitude of F-Layer maximum electron densities. Sputnik III made measurements of ion density and electron temperature to altitudes of 800 km and perhaps above.

The graph on page 27 represents a nominal picture of the afternoon, quiet ionosphere in mid-latitudes. With the exception of Soviet data, rocket-probe measurements taken prior to the IGY were used to chart this graph. Of course, fine structure in the ionosphere, which varies markedly from day to day, is missing from the representation. Unfortunately, it is not possible as yet to present similar material for the Arctic ionosphere, but complete analysis of the IGY results at Fort Churchill will give at least a partial picture to an altitude of perhaps 300 km.

With the exception of Soviet experiments, quantitative information on the ionosphere from satellite carriers has been disappointingly small. This is not surprising in view of preparations made by the Russians before the launching of Sputnik I in October 1957. The techniques employed by the Soviets included an ion trap aboard Sputnik III and extensive measurements of the times of "radio-dawn" and "radio-set" of the transmitting beacons carried aboard all their satellites. The first method yields a direct measurement of ion density and electron "temperature" at the satellite, while the second method furnishes a profile of the ionosphere below the satellite. The published Russian results, however, are in fair agreement with the graph on page 27.

The table on page 27 summarizes the principal techniques for ionospheric studies with rockets and satellites. The Langmuir Probe is one of the most promising techniques. Two preliminary models of the probe, designed and built at the Univ. of Michigan, as shown on page 26, were carried aloft by rockets at Fort Churchill in the closing months of the IGY.

Other geophysical experiments carried by rockets and satellites contributed to our knowledge of the ionosphere through less direct measurements. One of the more important of these is the study of small variations in the earth's magnetic field attributable to electric currents flowing in the ionosphere. Extremely sensitive magnetometers are used for this purpose, and a number of appropriately instrumented rockets were launched at various points on the earth in the IGY.

But, to go back a bit, after the exploratory efforts of Appleton and Barnett in 1925, it was natural that considerable work would be done to find a suitable mechanism for production of the observed ionospheric structure. In 1931, S. Chapman postulated such a mechanism (photo-ionization) and predicted the distribution of electrons and ions in altitude and solar position based on an atmosphere of uniform composition and mono-energetic solar radiation. Despite the general invalidity of the assumptions, the predicted distributions were quite good, particularly in the lower regions of the F-Layer.

The Chapman theory showed a parabolic distribution (number density vs. altitude) of charged particles and provided an excellent means for determining the rates of ion-electron recombination in the high atmosphere from observations with the pulse-delay vertical sounders. The photon radiation from the sun required by theory for the photo-ionization of the atmospheric gases lies in both the near- and far-ultraviolet regions of the solar spectrum and, unfortunately, is not observable at the ground. Consequently, the character of solar radiation in the spectral regions of interest had to be inferred from measurements in the visible spectrum, plus the assumption that the sun radiated like a black body at all wavelengths. The ultraviolet radiation thus inferred could not satisfactorily explain the observed structure of the D- and E-Layers, and further theoretical developments had to await the rocket research program initiated in 1946.

First Data

One of the earliest investigations undertaken by the Naval Research Laboratory in its rocket program was a systematic study and extension of the solar spectrum in the ultraviolet above the absorbing atmosphere. This investigation, which continues today, has had far-reaching consequences, not only in greatly expanding our

knowledge of solar processes but in explaining the formation of the lower ionosphere and adding to our information on atmospheric composition. The first results from the spectral studies showed that the black body temperature was lower in the near-ultraviolet than at visible wavelengths, and that indeed some source other than radiation from the sun's photosphere was necessary to explain the lower ionosphere.

As the studies continued, it became evident that quite strong solar emissions exist in the X-ray region and, further, that spectral line emission from atomic hydrogen in the solar atmosphere is very prominent. Both atomic and molecular oxygen have a transparent "window" at a wavelength corresponding to the wavelength of Lyman-Alpha hydrogen emission, and it was found that this emission was absorbed in the D-Layer of the ionosphere.

Persistence and good detective work led to the now generally accepted conclusion that nitric oxide was the responsible absorbing agent and that, indeed, the normal D-Layer could be quantitatively explained by Lyman-Alpha ionization of this constituent gas. In a similar fashion, the normal E-Layer can now be quantitatively explained by the ionization of molecular oxygen by soft X-rays. And, finally, the thickening of the D-Layer during a sudden ionospheric disturbance (SID) probably arises from hard X-rays emitted from the solar corona during large solar flares. This NRL work clearly illustrates not only the close solar-terrestrial ionosphere relationship, but also the great contributions of rocket research to our understanding of fundamental processes in the high atmosphere.

Perhaps a question has been raised in the reader's mind on the importance of the ionosphere to the science of astronautics. There are certain obvious answers, of course, when reference is made to the difficulties of communication and navigation with relatively low radio frequencies. The possibilities of utilizing the ionosphere, in its broadest sense, as an aid to communication and navigation are just beginning to be explored. The channeling of radio energy by ionospheric ducts or along magnetic lines of force may solve the power problem for interplanetary communications.

The really big payoff from the ionospheric research contemplated for the near future should come, however, in the form of burgeoning knowledge of geophysical, solar, and cosmic processes.

Based on a paper presented at the ARS Semi-Annual meeting and Astronautical Exposition held June 8-12 at the El Cortez Hotel, San Diego, Calif.

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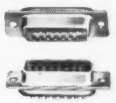

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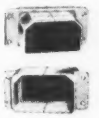

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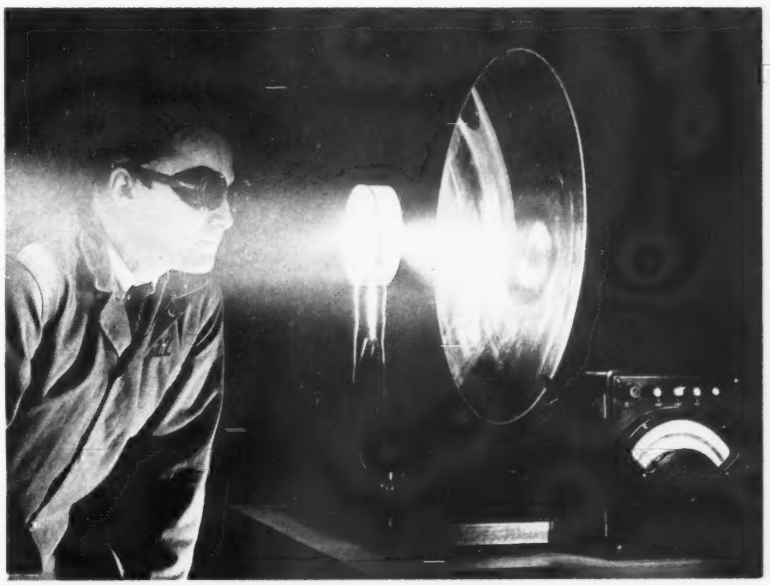
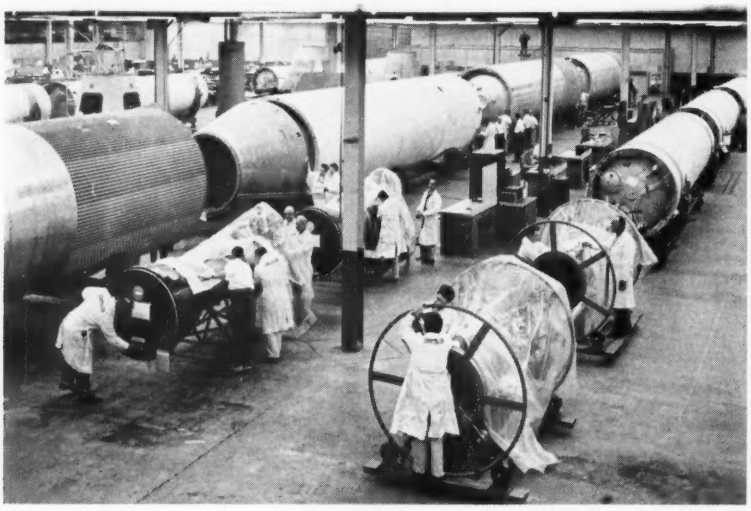
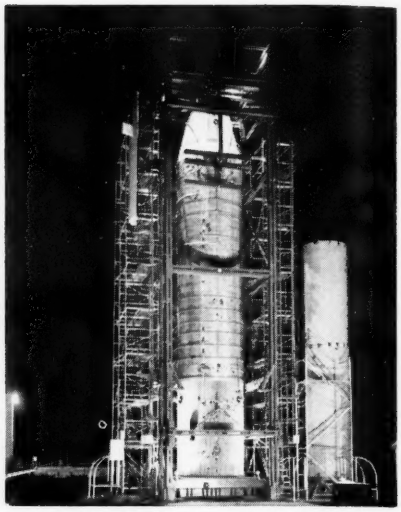


Power for Space Flight

J. C. R. Kelly Jr., manager of the Technology Dept., Westinghouse Research Laboratories, demonstrates thermoelectric converter being used in a study of space vehicle power sources. Dr. Kelly discussed thermoelectricity and showed several of its applications for the 40 high school students who competed in the annual Westinghouse Science Talent Search.

Chrysler Shows Jupiter, Redstone Production





Left, parallel production lines for Jupiter and Redstone missiles at Michigan Ordnance Missile Plant, operated by Chrysler for the Army. At right, Jupiter undergoes static testing at the plant. Propellant tanks, loaded with water and subjected to stresses expected in actual firing, are checked for leaks and structural integrity.

Chrysler produces Jupiter and Redstone ballistic missiles for the Army on parallel assembly lines at the government-owned Michigan Ordnance Missile Plant near Detroit. Within its single-level, 2.1-million-sq-ft floor space area, Chrysler engineers and technicians bring hundreds of thousands of parts together to form the missiles, and then test them under pressures, thrust, heat, vibration and other environmental conditions simulating actual flight.

Artificial Modification

(CONTINUED FROM PAGE 46)

tool, sodium release from rockets has provided an invaluable method of measuring upper-atmosphere winds and diffusion. Since the luminous cloud dissipates only after many minutes, its motion can be observed and photographed from the ground. Since a vertical sodium-vapor filament can be produced, an accurate vertical wind profile results, giving diffusion rates as well as wind-shears and turbulence. This tool will bear extensive future exploitation.

Materials other than sodium have been used to enhance and modify upper-atmosphere chemiluminescence. In the spring of 1956, nitric oxide gas was released at night from an Aerobee rocket at 105 km, producing a strong light emission of about −2 visual magnitude. From the luminous intensity and the time duration of the light, it is possible to explain the observations by the mechanism:

$$(6)\quad NO + O \longrightarrow NO_2 + h\nu$$

$$(7)\quad NO_2 + O \longrightarrow NO + O_2$$

$$(8)\quad O_2^* \longrightarrow O_2 + h\nu$$

$$(9)\quad NO + N \longrightarrow N_2 + O$$

Since diffusion alone cannot account for the time rate of decay of the light emission, step (9) is proposed to account for the apparent disappearance of nitric oxide. This might be considered as evidence for the existence of atomic nitrogen in the 100-km region.

This evidence was supported by the observations made on two clouds of ethylene gas released at night in the 100- and 140-km regions. A reddish glow at 100 km strongly suggests the occurrence of cyanogen bands, which could only have resulted from the interaction of ethylene with atomic nitrogen. At 140 km, the glow was bluish, probably due to atomic oxygen. While both atomic species are probably present at each altitude, the color difference is explainable on the basis of different reaction rates for the ethylene-atomic oxygen and ethylene-atomic nitrogen processes.

Other chemical agents may be preferable to ethylene for the detection of atomic nitrogen. What is required is a high reaction rate and a high luminous efficiency for the reaction with atomic nitrogen, and correspondingly low values of these quantities for the reaction with atomic oxygen. Some of the chlorinated hydrocarbons, such as methylene dichloride, seem promising in this regard.

One of the most interesting, and potentially valuable, results of upper-atmosphere modification experiments has been the production of ion-electron clouds. The first of these was successfully produced in 1956 with the release of nitric oxide gas at 95 km during daylight. Unfiltered solar radiation in the far ultraviolet is capable of producing photo-ionization of atmospheric gases. This, of course, can occur only at great altitudes, where the air density is too low for ultraviolet absorption to take place.

Solar ultraviolet is rich in the hydrogen Lyman-alpha line (1215.6 Å). This particular wavelength penetrates quite deeply into the atmosphere (down to about 85 km) because oxygen and nitrogen absorb it very weakly. Nitric oxide, however, has a very high photo-ionization cross-section for Lyman-alpha, and it was possible to calculate theoretically that a cloud of this material at 95 km would be photo-ionized, leading to an electron density of 10^6 per cc. Radar observations on the ground confirmed this prediction. In this case, the cloud persisted for 10 min with a density about 100 times greater than the ambient ionosphere.

Consideration of the results of this experiment immediately gave rise to the possibility of over-the-horizon propagation of electromagnetic radiation having higher than critical ionosphere frequency. The problem can be broken down quite simply. The

highest electron densities normally observed in the ionosphere are approximately 10^6 electrons per cc in the F-layer, 10^5/cc in the E-layer, and 10^4/cc in the D-layer. Clouds having greater electron densities should be capable of reflecting or scattering frequencies normally only propagated over line-of-sight distances. To produce such clouds, contaminating materials should possess a high photo-ionization cross-section, low ionization potential (so that they can absorb a large amount of solar radiation), and a low ion-electron recombination coefficient.

Up to the present, the alkali metals seem to be the most suitable. Of course, the ambient atmospheric gases play a vital role in the persistence of electron clouds. Assuming that one can choose a perfect contaminant, whose properties allow good ionization and slow recombination, the relatively high pressures of molecular oxygen, found below about 80 km, limit the persistence of electron clouds because of electron affinity for O_2^- ions. At much higher altitudes, low atmospheric pressure allows very rapid diffusion. It appears that the optimum altitude region is between 90 and 175 km.

Electron Cloud Experiments

During 1957 and 1958, numerous electron cloud experiments were performed by F. F. Marmo and collaborators using potassium, cesium, and sodium. Of these materials, cesium appears best. Electron clouds having densities approaching 10^8/cc have been produced. Forward propagation of higher than critical frequencies has been achieved. Techniques have been evolved which produce ionization thermally, thus making night operation feasible. Taking all aspects into account, artificial electron clouds will undoubtedly bear fruit in many practical applications.

At this point, it is useful to discuss some of the data still required in the evolution of the artificial modification field. Probably the most important work must be done in the laboratory. In interpreting field experiments, time after time one encounters difficulty because the rate of a certain reaction is unknown, or the chemiluminescent efficiency has not been measured, or a given absorption or photo-ionization cross-section is lacking. In the case of ion-electron recombination coefficients, almost no data are available. Indeed, some coefficients are not known within a factor of 10^6. Even the mechanism of the reaction between nitric oxide and atomic oxygen is unclear, let alone its chemiluminescent efficiency. Little work has been done on the rate of electron attachment to the oxygen molecule, a parameter of great importance. While some of the above quantities can be estimated from the rocket observations, laboratory experiments will be necessary for confirmation.

The use of organic gases such as chlorinated hydrocarbons will be enormously valuable in studying the composition of the upper atmosphere, particularly with respect to atomic oxygen and atomic nitrogen. Nevertheless, before these methods can be really complete, reaction rate constants and chemiluminescent efficiencies, as well as mechanisms, must be determined by laboratory work.

Against this background, we may speculate on the ultimate results to be sought from an exhaustive research program on atmospheric modification. Results from such a program are not necessarily limited to our own atmosphere. For example, charges of sodium vapor weighing only a few pounds can be visible, or at least photographable, from the ground at lunar or greater distances. The recent U.S.S.R. lunar vehicle provides striking proof of this. It should be possible to place a detectable sodium cloud on or near the moon. Future advances in rocket technology may make it possible to produce a temporary or even permanent change in the electron density of the earth's ionosphere, such that variations due to solar influence will be minimized. Of course, the most obviously attainable result will be a complete elucidation of the structure of the earth's upper atmosphere.

Suggested Additional Reading

The Airglow and the Aurorae, H. D. Edwards, J. F. Bedinger, and E. R. Manring, Pergamon Press, London (1956).

The Threshold of Space, F. F. Marmo, J. Pressman, L. M. Aschenbrand, A. S. Jursa, and M. Zelikoff, Pergamon Press, London (1957).

J. F. Bedinger, E. R. Manring, and S. N. Ghosh, *Journal of Geophysical Research*, 63, 19 (1958).

E. R. Manring and J. F. Bedinger, Proceedings of the VIIIth International Astronautical Congress, Barcelona (1957), pp. 253–256.

M. Zelikoff, F. F. Marmo, J. Pressman, E. R. Manring, L. M. Aschenbrand, and A. S. Jursa, *Journal of Geophysical Research*, 63, 31 (1958).

F. F. Marmo, L. M. Aschenbrand, and J. Pressman, Presented at U. R. S. I. Meeting, Washington, D. C. (May 1959).

ENGINEERS & SCIENTISTS

Research Opportunities

Aeronutronic Systems, Inc., a dynamic new name in science and research, has immediate need for qualified people to staff senior positions at its new *Research Center* in *Newport Beach*, Southern California.

The Space Technology Division of this rapidly expanding Ford Motor Company subsidiary has career openings in the following fields of interest:

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- High temperature structural plastics & ceramics
- Advanced structures
- Rocket vehicle systems

MISSILE DEFENSE
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- Aerothermodynamics
- High temperature heat transfer
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ASTRO SCIENCES
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Antennas

(CONTINUED FROM PAGE 45)

of velocity.

With the Doppler shift, a 1000-mc radio signal transmitted from a space vehicle receding from the earth with a velocity one-third the velocity of light would be received on the earth with a frequency of the 700 mc; and from an approaching vehicle it would be received with a frequency of 1400 mc. This is a bandwidth of 2 to 1 for the same transmitting frequency!

In the last few years, a certain amount of research has been done to obtain wide-band, omnipolarization antennas. In the microwave band, interesting results have been obtained with a cross-shaped ridge in a square waveguide, or with a conical ridge in a circular waveguide, as shown on page 45. With these devices, a bandwidth of 3 to 1–3 to 9 kmc, for example, can be obtained. This is an encouraging development, and it can be improved.

A new theory, called the angular concept, could lead us to the design of a very wide-band antenna. If an antenna is designed in such a way that its dimensions are defined only by angles, its performance is independent of frequency. Cones, defined by one angle, and spirals, defined by two angles, are good examples of this concept. In theory, it should be possible to design a perfect wide-band antenna by projection of an infinite spiral on the surface of an infinite cone. But even in the expanse of space we must compromise for practical purposes and use at least one linear dimension.

In space, the shape easiest to build is the sphere. The sphere has one linear dimension, its circumference, and can be used with the angular concept.

Let us take a plane equiangular spiral and project it onto the surface of a sphere. We obtain a spherical equiangular spiral. This form satisfies the angular concept approximately when the circumference of the sphere is larger than the maximum wavelength to be used.

The spiral is defined by its radius, ρ, which is the function of two angles —the pitch angle α, and the polar angle β, according to the relationship: $\rho = \epsilon^{\alpha\beta}$. The edges of a spiral *conductor* are identical curves, with one rotated through some fixed angle (γ) that represents the width of the conductor. It can readily be shown that a balanced (double) spiral conductor is perfectly defined by the three angles α, β and γ.

Now, a balanced spiral conductor projected on the surface of a sphere—specifically, metal-printed on a plastic balloon—could serve either as a dipole antenna, by means of the two metallic arms of the spiral, or as a slot antenna, by means of the gap between the arms of the spiral. The drawings on page 45 show these two antenna forms.

Which mode of the antenna might it be advisable to use? According to Babinet's principle, dipole and slot antennas are inverse, complementary structures with the impedance of the slot proportional to the admittance of the dipole, and vice versa. But, because in spiral form these antennas are curvilinear and longer than one-half wavelength, the dipole impedance is larger than for a nominal rectilinear half-wave form and has an inductive component, and the slot impedance is smaller and has a capacitive component.

There is a theoretical point, however, where both complex impedances have the same absolute value—at approximately 188 ohms. Experiment confirms this point approximately for a long spiral antenna.

Antenna Used As Slot

In practice, it seems preferable to use the antenna as a slot, which can be fed with a coaxial cable flush with one of the spiral conductors and does not require the use of a balun. Moreover, in that case, the coaxial cable does not interfere with the external radiation field of the antenna.

With respect to radiation field, the spherical spiral antenna has this interesting property. If the turns of the spiral are close enough, there are several turns for which the circumference remains very nearly equal to the wavelength. In this region, the currents in adjacent conductors are nearly in phase, which reduces the field between the conductors and increases the external radiation field, thus creating a radiation belt around the sphere.

A change in frequency merely causes the radiation belt to move back and forth on the surface of the sphere into a zone where the average circumference corresponds to the wavelength. As long as the wavelength stays within the limits of the sphere circumference, we can say that the performance of the antenna, defined only by angles, is independent of frequency.

As for the polarization, we know that in a circular structure, a helix for example, polarization is circular when the wavelength is approximately equal to the circumference. When the frequency is lower, and the wavelength larger than the circumference, polarization becomes elliptical and then linear.

Experiments made on plane spiral antennas have confirmed this fact; and we can expect the spherical spiral

Science, Engineering Degrees Up Sharply in 1957-58

The number of degrees awarded in the physical sciences, mathematics, and engineering rose sharply in the 1957–58 school year over the previous year, according to a report in the March 31 issue of the *Engineering and Scientific Manpower Newsletter*.

Bachelor degrees in engineering rose from 31,211 in 1956–57 to 35,332 last year, while bachelor degrees in the physical sciences were up to 14,352 from 12, 934 the previous year.

A comparison of the 1956–57 and 1957–58 figures follows:

	Bachelor		Master		Doctor	
	1956–57	1957–58	1956–57	1957–58	1956–57	1957–58
Physical Sciences	12,934	14,352	2,704	3,034	1,674	1,655
Mathematics	5,546	6,924	965	1,234	249	247
Engineering	31,211	35,332	5,233	5,788	596	647

Distribution of degrees in the physical sciences in 1957–58 was as follows:

	Bachelor	Master	Doctor
Astronomy	25	20	22
Chemistry	7,010	1,125	939
Meteorology	153	71	14
Physics	3,186	795	464
Earth Sciences	2,891	753	167
Unclassified	1,087	270	49
Totals	14,352	3,034	1,655

antenna to receive radio signals with nearly all polarizations and within a very wide frequency band.

The radiation pattern should be similar to that for a helix radiating in the axial mode—a single broad beam in the direction of the spiral axis—and the beamwidth should remain constant over a wide band of frequency.

Space antennas will have to be small while passing through the earth's atmosphere and large when in space. This leads us to the idea of a balloon. If we are to use a balloon, the spiral is probably the best antenna defined only by angles that can be built on its surface.

As far as we know, no research has been done yet in this very promising field. But it should be worthwhile to investigate in practice the efficiency of the spherical spiral antenna.

What is, at the present time, the maximum range of space communications?

With immediately available electronics, we need 10 watts to send a radio signal to the moon, 100 watts for Venus, and 300 watts for Mars. We can certainly reach Jupiter 400 million miles away and probably Saturn 800 million miles away. But if we want to receive a television picture from the moon, we need 300 k and this is quite a problem.

What is more, man can only reach the limits of our solar system with a space vehicle whose velocity approaches the velocity of light. Traveling near the velocity of light, he will have to face a new kind of problem. Relativity will cause the time, frequency and energy to change between transmitter and receiver. Photon energy, depending on frequency, will be different. Distortion in coordinates will concentrate the energy in the forward direction and create an aberration in the apparent location of the vehicle.

All these factors will affect the design of antennas for use in space. They will spur work on such new and radical concepts as the periodic antenna or the column of ionized gases following the vehicle. Ionization can be produced both by rocket exhaust during powered flight and by collision of the spacecraft with gas molecules at other times. That is, we know that interplanetary space is not a perfect vacuum and that vehicle velocity can compensate for the scarcity of the molecules. Such an antenna could probably be excited by a probe or loop.

It is difficult to imagine what will be the space antennas of the future, but we can already be sure that they will play an important part in space communications.

Navy Shows Off Operational High-Altitude Pressure Suit

Hinting that with some alteration this could be the spacesuit for the Mercury astronaut, the Navy demonstrated recently a Mark IV high-altitude full-pressure suit, developed by B. F. Goodrich Co., in which a pilot's in-suit environment never exceeds 35,000 ft altitude.

At its Naval Air Crew Equipment Laboratory, Philadelphia, the Navy showed how the Mark IV was able to withstand 19 g, −60 F ambient temperature, and −27 F water temperature. Human experimenters using the Mark IV have endured such temperatures for more than 7 hr. The suit will also endure ambient temperatures as high as 158 F. During explosive-decompression simulation, a Navy technician shot from 27,000 ft to 60,000 ft in 60 millisec, and then up to 100,000 ft altitude, exhibited no more discomfort than nervous tension. His suit pressure never exceeded 3.4 psi, which, the Navy claims, can be maintained even in vacuum.

Currently, the Mark IV is being used by Navy squadrons flying F8U Crusaders and in test flights of F4H and A3J aircraft. Outstanding is its survival feature in the event of emergency ejection. For example, should a pilot eject at the blood-boiling altitude of 65,000 ft or higher, a bailout oxygen supply integrated into the gear would pressurize the suit and also supply breathing oxygen for 30 min. The suit weighs only 20 lb and costs about $3000.

Navy technician in Mark IV suit readies himself for 19-g ride.

An auxiliary piece of equipment is a compact ventilating and breathing package weighing about 18 lb that fits to the Mark IV. Good for 1 hr operation, it was developed by The Firewel Co. which believes that the unit may be used during construction of manned space stations.

RMI Catapult System For Navy Ups Capacity 50%

An aircraft carrier catapult system designed and built by Thiokol's Reaction Motors Div. for the Navy increases plane launching capacity by 50 per cent—launching heavier planes and launching them faster. This is achieved with an independent—of ship's boiler system—powerplant.

Because it accelerates the aircraft at a constant peak pressure during the entire launching operation, the pilot doesn't feel the big kick inherent in current steam catapults. Heart of the powerplant is the servo control, which positions the air, JP-5 fuel, and water control valves to maintain constant cylinder pressure throughout the launching stroke.

Firetrac Measures Near Misses

Aerojet-General has developed a missile tracking system, for Navy BuAer, which accurately measures relative trajectory, velocity, and miss-distance of a missile with respect to a target drone at which it is fired. Tagged Firetrac, it will help in the design of better missile systems and more accurate guidance fuzing subsystems.

French Antitank Missile Slated for 7th Army

The French SS-11 wire-guided antitank missile, shown here on Republic Aviation's Alouette II jet helicopter, will equip the U.S. 7th Army in Germany. Powered by a light boost-thrust solid-propellant motor, the missile can be launched and guided from the ground by a foot soldier, as well as from a moving platform.

New equipment and processes

X-Ray Film Processor: Radiographs can be processed automatically with the X-omat processor, which delivers a dry film in 13 min. The equipment handles all listed sheet sizes of Kodak X-ray film, types AA and M, most widely used in quality control, and accepts continuous lengths of roll film 17 in. wide. Eastman Kodak Co., Rochester 4, N.Y.

Decimal Scaler: Designed for general radiation counting, Model SC-700 especially suits accelerator counting room service. The instrument features seven decades of decimal count storage, stable feedback input amplifier with 25-mv sensitivity, precision integral discriminator, and built-in line frequency test circuit. Weight, 16 lb. Eldorado Electronics, Berkeley, Calif.

Tape Speed Check: Tapestrobe determines speed of magnetic tape by a wheel bearing stroboscopic markings, mounted on a frame, and placed against the moving tape. An ordinary 60-c light source furnishes the basic timing. When the wheel pattern seems to stand still, the tape is on speed. Scott Instrument Laboratories, Inc., 17 E. 48 St., New York 17, N.Y.

Thrust Control: This closed-loop device meters hydrogen peroxide to rocket engines used as auxiliary powerplants on manned aircraft or missiles. The complete system weighing 7.3 lb includes a magnetic amplifier, pressure transducer, and metering valve. Bendix Aviation Corp., Bendix Products Div., South Bend, Ind.

Liquid Level Switch: A miniature glass-aluminum sensing element for use with low boiling point fluids has been developed. The sensor is used with an external miniaturized control unit. Together they form an ultrasonic liquid-level switch for cryogenic liquids. No current is applied to the element, and it is therefore sparkproof. Typical unit weighs 7 oz. Acoustica Associates, Inc., 26 Windsor Ave., Mineola, N.Y.

Commutator-Gating Units:: Electromechanical CAG Series high level commutator gating units accommodate inputs ranging from 0 to 5 v full-scale, as produced by various standard signal sources, such as potentiometers, cathode followers, and voltage references. A single subminiature, ruggedized vacuum tube is used to achieve the high impedance. General Devices, Inc., P.O. Box 253, Princeton, N.J.

Hydraulic Motorpumps: Available in a series, the pumps circulate coolant oil at low pressure around the high output tubes of missile electronic gear. Other applications are missile skin cooling, electronic chassis cooling, fuel and lubricant pumps, radar and computer drives, and remote power supply. Dry weight, 5.3 lb. Vickers, Inc., Detroit 32, Mich.

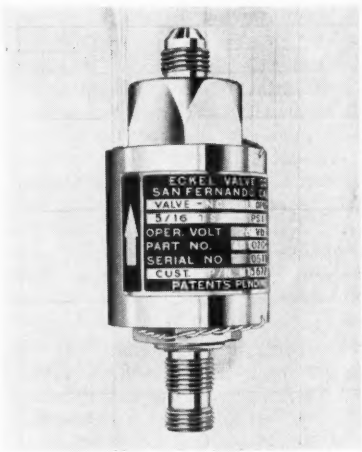
Linear Power Actuator: The actuator, which employs an electromagnetic clutch-brake, adapts to both missile and industrial applications. Specifications are: Normal load, 7500 lb; travel rate, 0.140 ips; stroke, 2.5 in; max. operating load, 15,500 lb; proof load, 28,000 lb. Weight, 18 lb. Hoover Electric Co., 2100 S. Stoner Ave., Los Angeles 25, Calif.

Shutoff Valve: Designed to operate at −35 to 160 F with a response time of 0.5 to 1.5 sec., a remotely controlled propellant shutoff valve weighs $16^1/_2$ lb. It will pass a flow of standard liquid fuels at the rate of 2000 gpm with a pressure drop of 0.31 psig. The gate valve can be controlled electrically or mechanically, and is adaptable to pneumatic or hydraulic actuation. Clary Dynamics, 408 Junipero St., San Gabriel, Calif.

Axial Blower:: Fitting in a 3-in.-square envelope and weighing only 14 oz, the blower delivers up to 169 cfm, operating on 115 v or 200 v a.c. Housing and propeller are cast aluminum. Power input at peak air volume is 120 w. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

TV Camera Lenses: For use with industrial television cameras, "nonbrowning" lenses will withstand 10^6 r of gamma radiation (cobalt 60) at the rate of 240 r/min with less than 5 per cent browning for the wavelength region 4500 to 7000 A. Loss is greatest at the shortest wavelength. Wollensak Optical Co., Rochester 21, N.Y.

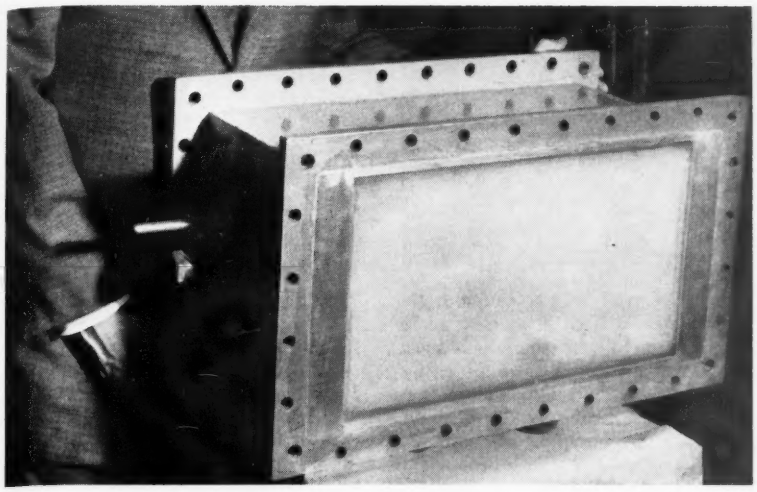
Coaxial Propellant Valve: A small coaxial dithering valve meters hydrogen peroxide, UDMH, anhydrous hydrazine, and other liquid propellants. Solenoid operated, the valve is compact, low in weight, and draws little power. Customed designed for specific applications. Eckel Valve Co., 1424 1st St., San Fernando, Calif.



Rescue Helicopter Carries Fire Extinguisher Pod

Aimed primarily at recovering crash victims, with emphasis placed on speed and mobility over any terrain, a new USAF crash-rescue system uses a Kaman helicopter to carry Janitrol extinguisher pod on its cargo hook. At the alert, the helicopter and crew snatch the pod from its trailer and fly to the crash site. The 1000-lb pod includes 850 gal of pressurized foam, hose and lightweight nozzle, axes, bars, sheet-metal cutters, and other tools. Operational radius is 75 miles. Detachment of the pod is automatic on touchdown, or by the pilot during flight. It can also be released by crewmen outside. Janitrol Aircraft Div., Surface Combustion Corp., 4200 Surface Rd., Columbus 4, Ohio.

Janitrol Aircraft CO_2-Foam Pod



Waveguide Window

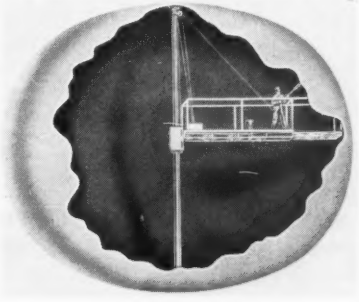
One of the largest waveguide windows ever produced, a new I-T-E window achieves high power handling capabilities through use of a crosslinked polystyrene as the mechanical barrier. The window is fitted into a milled groove in the waveguide flange and bolted to the flange through a retaining sheet and base flange. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.

Beacon Transmitter: This miniature, low power combination subcarrier oscillator and transmitter, for use in satellite or space vehicle tracking systems, is identical to the transmitter used in the Atlas "talking satellite" (Project Score). It is 3.25 in. in diam, has a total power consumption of 250 mw from a 20-v supply, and weighs 12 oz. (Not available in production quantities.) Applied Science Corp. of Princeton, P.O. Box 44, Princeton, N.J.

Horizontal Situation Indicator: A new HSI, used by the Air Force on integrated instrument panels, represents a plan view of the aircraft with respect to the entire navigation system. It provides a flight director steering and navigation situation on two 5-in. instruments bracketed by two vertical scale indicators. The instrument can be tied in with various flight director and automatic pilot systems. Collins Radio Co., Cedar Rapids, Iowa.

Missile Gyros: A spiral "clock" spring spins the rotor of this roll-reference gyro for missiles and drones. The frame-mounted spring brings the rotor to operational velocity in less than 10 millisec; the spring then disengages and permits the gyro to function as an inertial reference. Whittaker Gyro Div., Telecomputing Corp., 16217 Lindbergh St., Van Nuys, Calif.

Work Platform for Spheres: Especially designed for working inside spheres, a scaffold of all-welded steel construction has a revolving ring attached to a snatch block. Longitudinal sections of the work platform telescope as they approach the top or bottom. The assembly can be rotated to reach all parts of the sphere. Atlas Industrial Corp., 849 39th St., Brooklyn, N.Y.

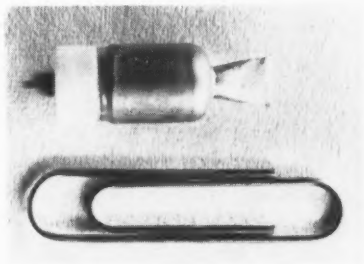


Humidity Indicator: Relative humidity can be indicated electronically from as far as 100 ft away by the portable Electro-Hygrometer. Humidity range, 30 to 95 per cent, within a temperature range of 32–180 F, with an accuracy of ±5 per cent. The device can be used to determine humidity inside difficult to reach places. Labline, Inc., 3070 W. Grand Ave., Chicago 22, Ill.

Pneumatic Gauge Tester: For use as a primary standard in gauging and calibrating all instruments measuring pressure, a new instrument features a range of pressures from 0.20 to 500 psi. Power requirements, 105 to 124 v, 60 cps, 3 w. Self-contained pressure source plus provision for external source; built-in pressure bleed valve. Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.

Gas Regulators: Designed not to need gauges, new rugged industrial gas regulators handle oxygen, acetylene or propane on cylinders or manifolds. Delivery pressures are calibrated on a plate on the cap of the regulator. Pressure is shown by an indicator running in the slot alongside of the calibrated reading. Linde Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York, N.Y.

Voltage Regulator Tubes: A new line of ruggedized subminiature metal-ceramic corona discharge voltage regulator tubes covers a range of 400–4000 v. The tubes operate over a temperature range of −55 to 200 C. Dimensions: Length, 0.65 in. (excluding tabulation and anode pin); OD, 0.3 in. Radiation Research Corp., 1114 First Ave., New York 21, N.Y.



Decade Dividers: A new line of solid-state decade dividers provides accurate frequency dividing or timing pulses with the minimum of components, size, and power consumption. The devices are available in three forms: Type DC-190, individual 10 kc decades; type DC-191, individual 100 kc decades; and type DC-195, complete 5-decade time base unit with 100 kc crystal source. Burroughs Corp., Electronic Tube Div., Box 1226, Plainfield, N.J.

Expanding the Frontiers of Space Technology in

THERMO-DYNAMICS

■ Lockheed's capabilities in gas dynamics and thermodynamics are unsurpassed in private industry. Basic work is being performed in boundary layer flow and heat transfer; cooling and insulation; thermodynamic flight test; instrumentation; rocket motor controls and nozzle structures; reentry and materials; thin film thermometry; and measurements of dissociation and recombination reactions.

Fundamental studies include hypersonic aerodynamics; environmental effects on satellite surfaces; magnetohydrodynamics; ultra-violet and infrared radiation from high temperature air flows; structure of hypersonic shock waves; new measurement methods; analysis of boundary layers near melting surfaces and study of lag or nonequilibrium in high speed flow through shock waves.

Latest equipment includes an electrically-driven wind tunnel fastest in industry—which produces air flows to Mach 20-plus and stagnant temperatures approaching 16,000°F, with an instantaneous power output of 20 million kilowatts. A spark-heated, magnetically driven research shock tube produces velocities of over Mach 250 and temperatures of 500,000°F. A specially designed electric gun has accelerated projectiles to speeds approaching 20,000 ft/sec.

ENGINEERS AND SCIENTISTS

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown environments. If you hold a degree and are experienced in thermodynamics or have background in related work, we invite your inquiry. Write: Research and Development Staff, Dept. G-14, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

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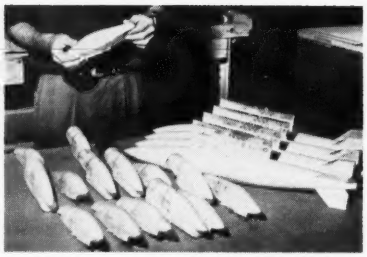


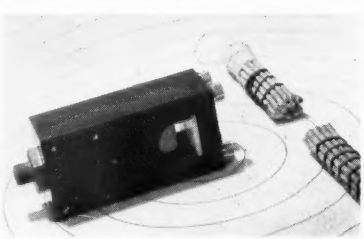
Urethane Foam: Wind tunnel tests can be made with low cost scale models of molded urethane. Models made too light initially can be easily weighted where needed. The foam can be made flexible or rigid, light or heavy, by varying formulations. Allied Chemical Corp., 61 Broadway, New York 6, N.Y.

Miniature Clutches: One-way precision roller clutches, that allow drive in one direction and provide freewheeling action in the opposite direction, are available in four sizes custom designed to user's housing. Stock roller assembly sizes range from 0.1875 in bore and 0.625 in o.d., through 0.625 in bore and 1.625 o.d. Right- or left-hand drives are offered. The Miniclutch Co., 373 Morse St., Hamden, Conn.

Two-Way Valve: Gives independently controlled flow in either or both directions; adapts to hydraulic or pneumatic applications with pressures up to 5000 psi. Available in standard sizes from $^1/_8$ to $^3/_4$ in., and in brass, steel, aluminum, stainless, and special alloys. Adjustments may be made with a screwdriver. True-Flo Valve Co., 79 Bow St., Everett 40, Mass.

Welding of Molybdenum: A technique which makes it possible to satisfactorily spot-weld molybdenum sheets produces a weld by fusing only the molybdenum in the immediate vicinity where the lapped sheets contact. Less than half the original sheet thickness is affected by the weld. A technique to produce a fusion weld with good ductility without acid etching has also been developed. T. R. Finn and Co., Inc., Hawthorne, N.J.

Cable Guillotine: Powered by a standard explosive shell, the guillotine sends a ceramic knife through a cable bundle and onto a ceramic anvil. The ceramic components prevent shorting in the cable bundle during the cut. Beckman & Whitley, Inc., 985 E. San Carlos Ave., San Carlos, Calif.



PRODUCT LITERATURE

Electronic cooling packages. Pesco Products Div., Borg-Warner Corp., 247000 N. Miles Rd., Bedford, Ohio.

Mincom model c-100 instrumentation. Mincom Div., Minnesota Mining & Mfg. Co., 2049 S. Barrington Ave., Los Angeles 25, Calif.

Consolidated's computing galvanometer. Consolidated Electrodynamics Corp., Transducer Div., 300 N. Sierra Madre Villa, Pasadena, Calif.

Ruggedized displacement gyro. Lear, Grand Rapids Div., 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

Electronic tachometer. Airpax Electronics, Seminole Div., Fort Lauderdale, Fla.

Automatic indexing X-ray spectrograph. Philips Electronics, Inc., Instruments Div., 750 S. Fulton Ave., Mt. Vernon, N.Y.

Triple point of water cell. Trans-Sonics, Inc., P.O. Box 328, Lexington 73, Mass.

Sweep generators. Telonic Industries, Inc., Beech Grove, Ind.

Temperature measurement system and components. Cardinal Instrumentation, 4201 Redwood Ave., Los Angeles 66, Calif.

Absolute pressure transducer. Bourns Laboratories, Inc., Riverside, Calif.

Linear comparator. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

Hot-wire anemometer. Shapiro & Edwards Electronic Instrumentation, 1130 Mission St., S. Pasadena, Calif.

Spec-power. National Spectrographic Laboratories, Inc., 6300 Euclid Ave., Cleveland 3, Ohio.

Camera selector. Traid Corp., 17136 Ventura Blvd., Encino, Calif.

Magnetic tape recorder. Data Tape Div., Consolidated Electrodynamics, 300 N. Sierra Madre Villa, Pasadena, Calif.

Rotating components. Beckman/Helipot, Helipot Div. of Beckman Instruments, Inc., Fullerton, Calif.

Digital instrumentation. Computer Measurements Co., Div. of Pacific Industries, Inc., 5528 Vineland Ave., N. Hollywood, Calif.

New concepts in recording. Brush Instruments, Div. of Clevite Corp., 37th and Perkins, Cleveland 14, Ohio.

Wiancko fm systems. Wiancko Engineering Co., 255 N. Halstead, Pasadena, Calif.

Precision wirewound potentiometers. Maurey Instrument Corp., 7924 S. Exchange Ave., Chicago 17, Ill.

Mercury switches. Micro Switch, A Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Pressure transducers. Bourns Laboratories, Inc., Riverside, Calif.

Selenium rectifiers. Rectico, Inc., 963 Frelinghuysen Ave., Newark 12, N.J.

Servo motors, motor generators, synchros. Kearfoot Co., Inc., Little Falls, N.J.

Battery-operated spring-motor tape recorders. Amplifier Corp. of America, 398 Broadway, New York 13, N.Y.

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Stairway to Space . . .

MANHIGH III piloted by Lt. Col. David G. Simons, USAF-(MC) holds the world record altitude for manned flight: 101,500 feet. The East German Government selected this published photograph to commemorate IGY on this postage stamp. As in four other notably successful manned high altitude research flights—Winzen Research Inc. was the contractor for the entire balloon/capsule system and flight operations.

Ancient Chinese used both the balloon and the rocket. These means of travel *still* represent the only stairways toward space flight. It seems amazing but, basically, we still haven't come up with something radically new! Until we do, let us use both stairways to space for greater effectiveness.

There are nearly 200 practical reasons why balloon flights are desirable today. The balloon complements the rocket. Among other reasons it offers:

1. *Extended flight time* free from vibrations, oscillations and noise of any kind. It will simulate orbital or space flight.
2. *Low cost.* A manned space-equivalent balloon flight costs less than 10% of the price of a modern fighter plane.
3. *Great flexibility.* The balloon platform offers a stable test bed for rocket components or complete capsules, a Skyhook for re-entry experiments, a medical laboratory for the study of human factors.

Whether you are interested in space medicine or space engineering—the balloon offers you stable, laboratory-type control under the only real environmental conditions—the space equivalent milieu near 100,000 feet.

During five flights, Winzen Research has been at space equivalent levels longer than all the other manned space probes of all nations added together. Perhaps this is why our activities are internationally recognized through the medium of a postage stamp.

How can we help you solve your space problems?

WINZEN RESEARCH INC.

"Space Research For A Decade"

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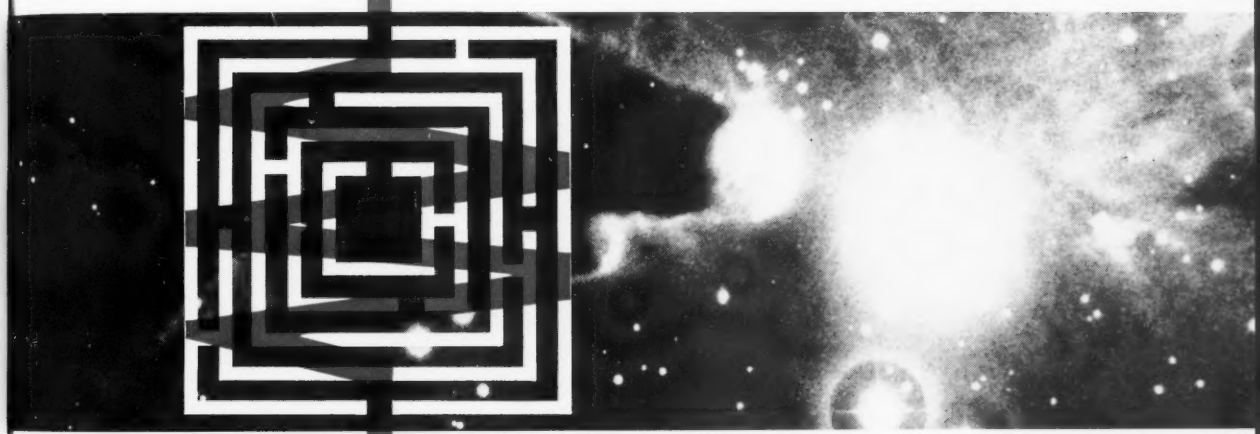

COMPUTATION FOR THE SPACE AGE

PEDITIONS INTO SPACE FOLLOW TRAILS BLAZED BY COMPUTATION SPECIALISTS. IN THIS HIGHLY PHISTICATED TECHNOLOGY, BURROUGHS CORPORATION'S DEMONSTRATED COMPETENCE RANGES FROM SIC RESEARCH THROUGH PRODUCTION TO FIELD SERVICE AS PROVED BY PROJECTS SUCH AS THE AIR RCE ATLAS. BURROUGHS CORPORATION IS EQUIPPED BY ABILITY AND ATTITUDE TO FUNCTION AS A AM MEMBER—A CLEARCUT RECOGNITION THAT EVEN IN THE REACHES OF OUTER SPACE, THE SHORTEST STANCE BETWEEN TWO POINTS IS SINGLENESS OF PURPOSE APPLIED TO MUTUAL OBJECTIVES.

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THE U.S.A.F. STRATEGIC AIR COMMAND - UNDERWRITERS OF

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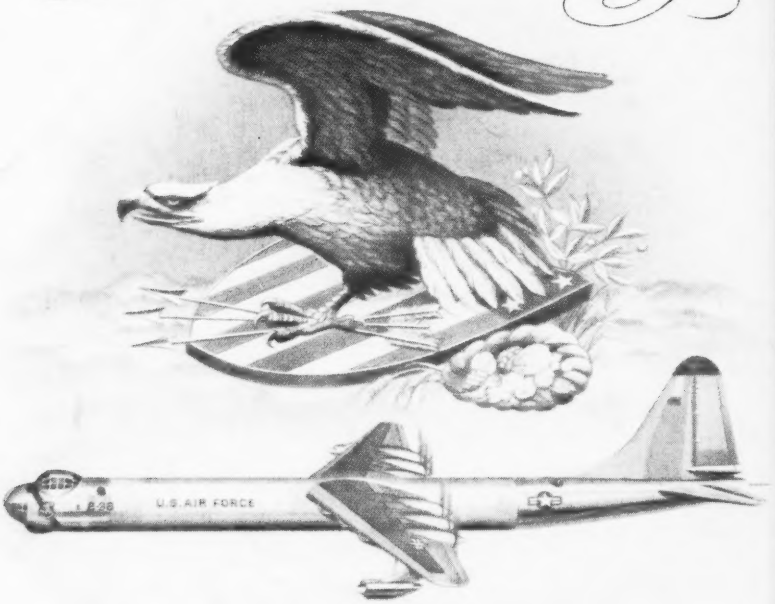
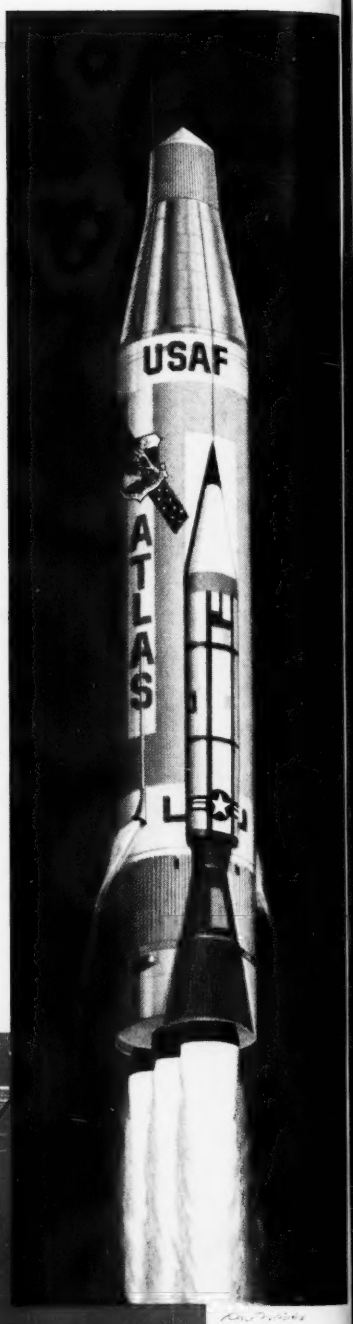
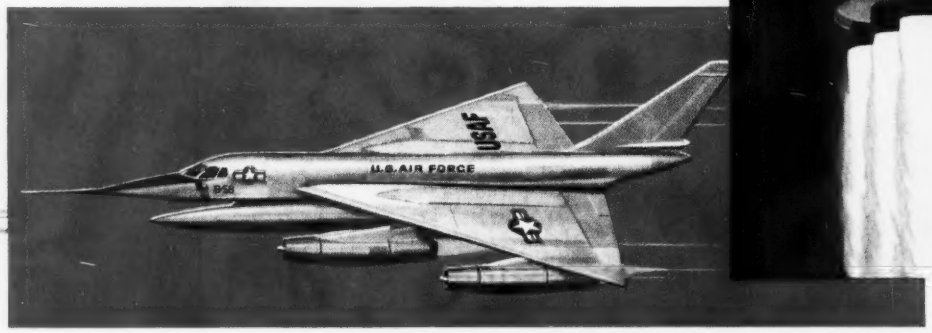


THE BENEFICIARY

Free People Everywhere





Convair's B-36 and the USAF Strategic Air Command combined to deter aggression and to prevent global conflict during the decade 1948-1958—the most critical period in all of history.

As the ultimate development of piston-engine aircraft, the *B-36 became an unequalled instrument of our national policy to maintain world peace.* The *B-36 proved to America and to the world that airpower is peace power!*

And now, to continue peace through airpower, Convair, a Division of General Dynamics, has designed and is producing the B-58 Supersonic Bomber and the Atlas ICBM—both assigned to the dedicated airmen of the Strategic Air Command who have established that *Peace is Their Profession.*

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